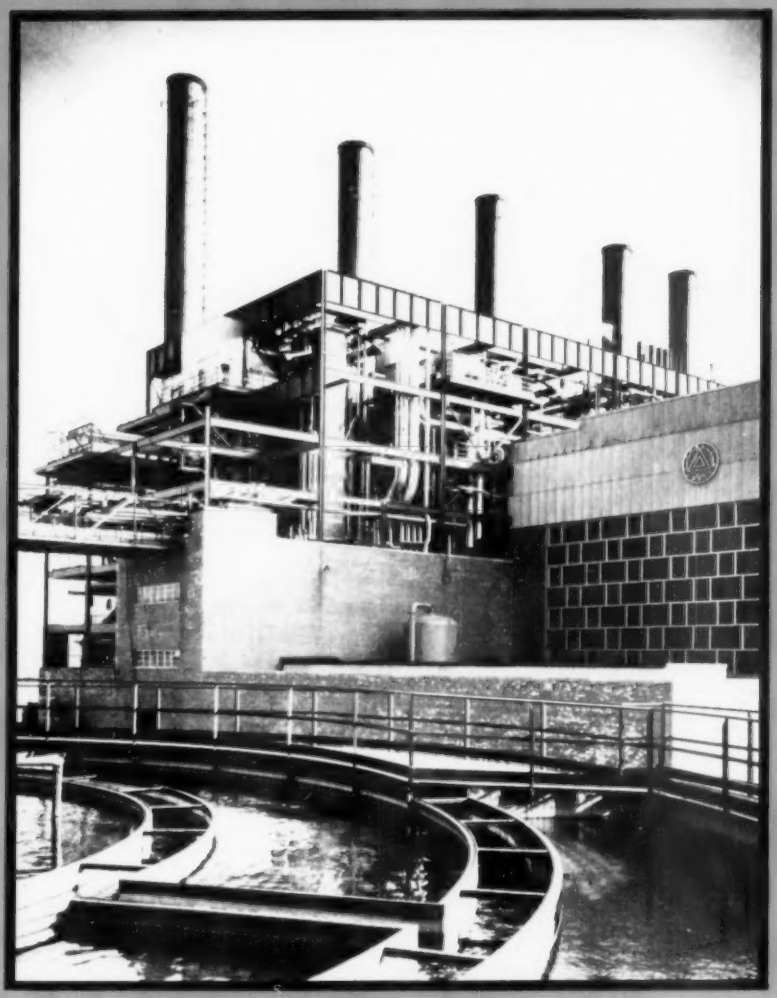
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

December 1958



View of circulating water canals and outdoor structures, Linden Generating Station, Public Service Electric and Gas Co.

The Boiler Feed Pump Drive

Shot Cleaning of Boiler Surfaces

Steam Station Ventilation

ASME Annual Meeting—I

Unusual past... bright future...

for the World's largest wine tanker

S.S. Angelo Petri was built by Bethlehem's San Francisco yard.

The S.S. Angelo Petri, America's first wine tanker, is certainly a most unusual ship. Representing a pioneering venture on the part of United Vintners, Inc., the vessel is unique in several respects. Because she was designed to transport a cargo so dependent upon high standards of purity and flavor, her main cargo tanks and all connecting piping and valves are of stainless and stainless clad steel—1,800,000 pounds of it in the tanks alone.

The ship has an unusual past. The entire after section was originally that of a T-2 tanker which broke in two in a storm. The machinery section was salvaged and towed to Anchorage, Alaska, where it provided electric power to the city for some years. Now, provided with entirely new bow and cargo sections, this extraordinary ship is back at sea. And the same C-E boilers that powered her, first as a World War II tanker and then as a floating power station, are doing the same reliable job for the S.S. Angelo Petri.

COMBUSTION ENGINEERING

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT. NUCLEAR REACTORS. PAPER MILL EQUIPMENT. PULVERIZERS. FLASH DRYING SYSTEMS. PRESSURE VESSELS. SOIL PIPE.

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 30 **No. 6**

December 1958

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BPA

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Turbines operate closer to maximum efficiency with

Hagan Steam Temperature Control

The closer turbines can operate to their maximum design temperature, the more efficient their operation. Hagan's steam temperature control system permits a closer approach to this optimum figure through extremely sensitive temperature measurement and the maintenance of very stable control despite narrow proportional band settings.

The chart shown is from Commonwealth Edison's Will County Station, and is typical of the results produced by this Hagan system. Utilizing Hagan's PowrAmp for amplification, the system is sensitive to temperature changes of 1°F or less. Ratio Totalizers are employed for derivative action, as controllers and for signal combining. For example, the system includes a signal from steam flow so that load changes can be anticipated.

Valves and dampers are operated by Hagan Power Positioners, which provide the necessary power, accuracy and speed to keep up with the rest of the system. The use of a suppressed scale enables the system to maintain closer control, and the high stability of the system permits fully automatic control, even under fluctuating loads.

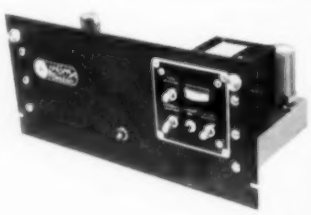
Hagan steam temperature control systems are in use on all types of boilers. Temperature control is achieved by flue gas recirculation, by various types of attemperation, by split firing, by burner tilt or by a combination of these methods. Temperature sensing and amplification may be either pneumatic or electronic, as shown below.

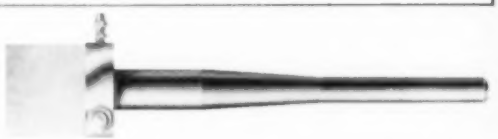
A Hagan engineer would be glad to explain exactly how a Hagan system can add to production efficiency. Write or phone Hagan at the address below, or the Hagan office nearest you.

HAGAN CHEMICALS & CONTROLS, INC.

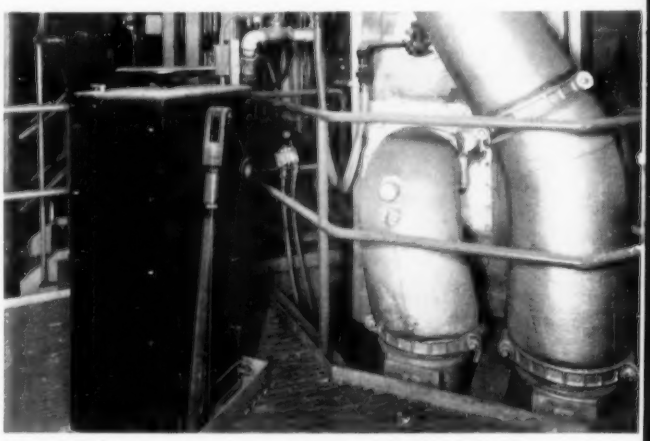
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY • HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

Hagan PowrAmp Amplifier is used with thermocouples for high speed response and ± 0.25% accuracy. Sensitive to very small temperature changes, PowrAmp equipment has a high degree of stability, and permits very close approach to optimum operating temperatures.



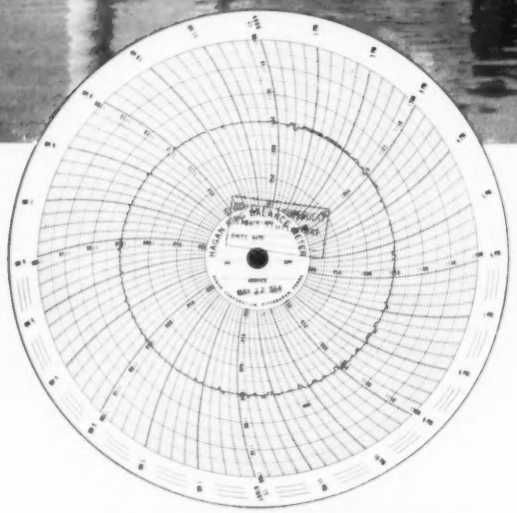


Hagan Pneumatic Thermostat provides practically instantaneous response to temperature changes and a high degree of accuracy. Generating a pneumatic output signal, it is suitable for measuring and controlling temperatures up to 1200°F at static pressures up to 2400 psig.



Hagan 8 x 14 Power Positioner controlling burner tilt. Precise and rapid response to control signals provides maximum possible regulation of superheat temperatures, reducing need for attemperation.

Will County Station, Commonwealth Edison Company, has Hagan Steam Temperature Control on Unit No. 3.

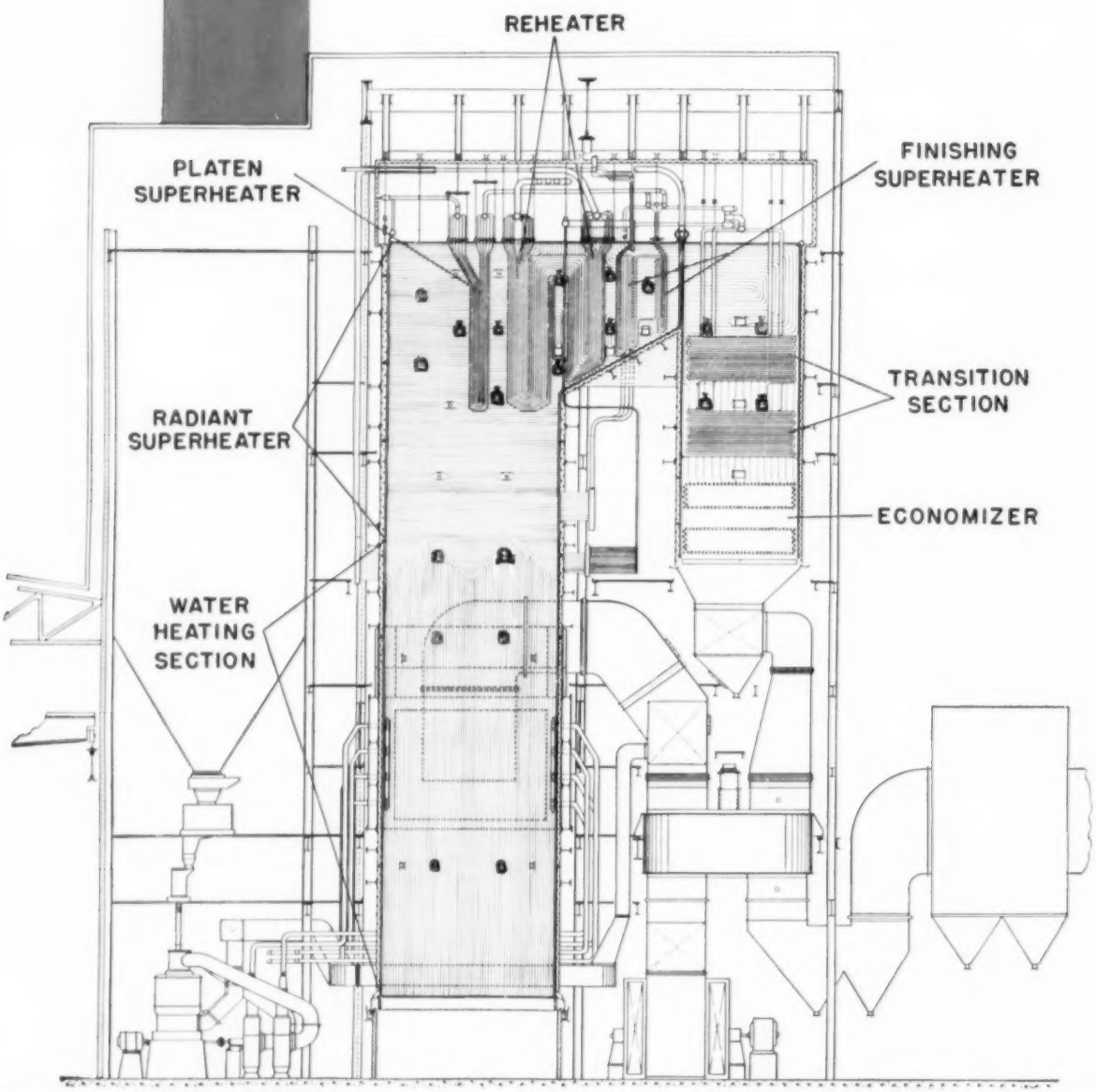


Typical superheat steam temperature chart with Hagan control. Note that chart range is 900° to 1200°, so that maximum swing recorded is approximately 5°.

These are some of the Electric Utilities who have purchased Hagan Steam Temperature control systems for one or more units:

Arkansas Power & Light Company
Carolina Power & Light Company
Commonwealth Edison Company
Consolidated Edison Company of New York, Inc.
Detroit Edison Company
Duquesne Light Company
Missouri Public Service Company
Montaup Electric Company
Niagara Mohawk Power Corporation
Orlando Utilities Commission
Tampa Electric Company
Texas Power & Light Company

Vulcan Selective-Sequence System picked for



The Cleveland Electric Illuminating Company
Avon Station Turbine Unit #8—Boiler #11
CE Sulzer Design
Boiler Capacity—1,715,000 lbs. per hour
Turbine Capability—250,000 KW
Steam Conditions at Turbine Throttle—3500 PSIG—1100F—1050F

Soot Blowing
Avon Station

The Cleveland Electric Illuminating's new super-critical pressure unit at Avon Station will be equipped with Vulcan T-3-E long retractable soot blowers, RW-3E wall deslaggers and air-preheater cleaning controls. Blowing medium will be air with emergency steam stand-by—from existing boilers. Air will be furnished by a centrifugal air compressor. Selective-sequence control will provide precisely the sequence necessary for the most effective cleaning. Blowing sequences can be varied from a compact, pre-wired control board simply by means of patch cords. Thus, any blower can be operated at any point in the sequence. The entire cycle can be set to run automatically to completion, to recycle or to operate under clock control.

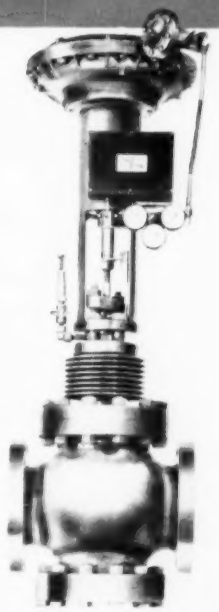
Modern Copes-Vulcan soot blowing systems such as the selective-sequence to be installed at Avon Station can help to keep your boilers operating at peak efficiency. Your Copes-Vulcan representative has the ideas, information and experience to help you make the selection best suited to your operation.

COPES VULCAN

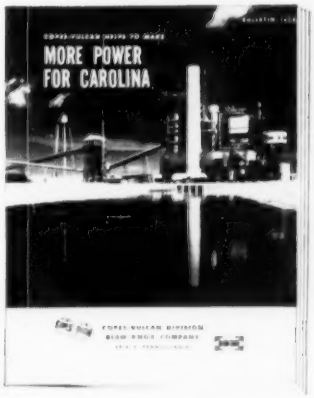
BLAW-KNOX

COPES-VULCAN DIVISION
BLAW-KNOX COMPANY
ERIE 4, PENNSYLVANIA

C-V NEWS NOTES

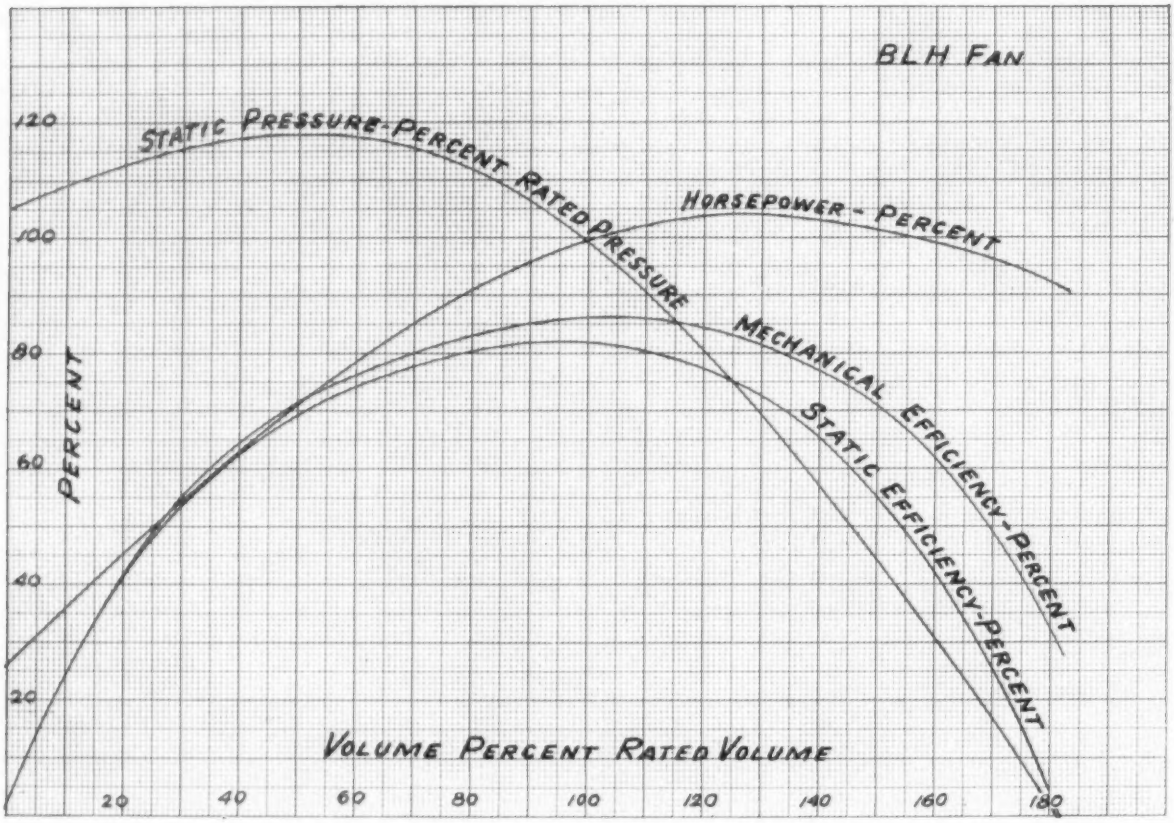


New Copes-Vulcan diaphragm-type CV-D valves have high rangeability, are either reverse or direct acting. They can be applied in sizes up to 12 inches at unlimited pressures.



Copes-Vulcan boiler control at Louis V. Sutton Steam Electric Generating Plant of Carolina Power & Light Company is described in Bulletin 1032. Your Copes-Vulcan man has a copy for you, or you may wish to write direct.

Unit 8 at Avon Station will get Copes-Vulcan pressure reducing and desuperheating station for energizing back-up soot blower steam supply. Copes-Vulcan desuperheaters will provide close control for all loads from 0 to 45,000 pounds per hour, with virtually instantaneous cycling.



When Mechanical Draft Specs meet them with "BUFFALO"

"BLH"—For Classes III & IV Mechanical Draft Service

The "Buffalo" Type "BLH" Fan is specifically designed to deliver peak efficiency, dependability and serviceability for Classes III and IV mechanical draft requirements. The "BLH" maintains its high mechanical efficiency of 86% over an extremely broad operating range. The "BLH" insures a constant stability of performance from free delivery to shutoff. Many unusual design features contribute to the smooth, quiet, powerful operation of the "BLH". A smooth inlet bell, directional inlet vanes, backward curved blades, specially curved rotor flange and divergent outlet reduce turbulence to an absolute minimum.

You'll appreciate the "Q" Factor in all "Buffalo" Fans — the built-in

To enjoy the efficiency benefits of the "BLH" in Classes III and IV mechanical draft installations, contact your nearest "Buffalo" representative — or write for Bulletin F-200.

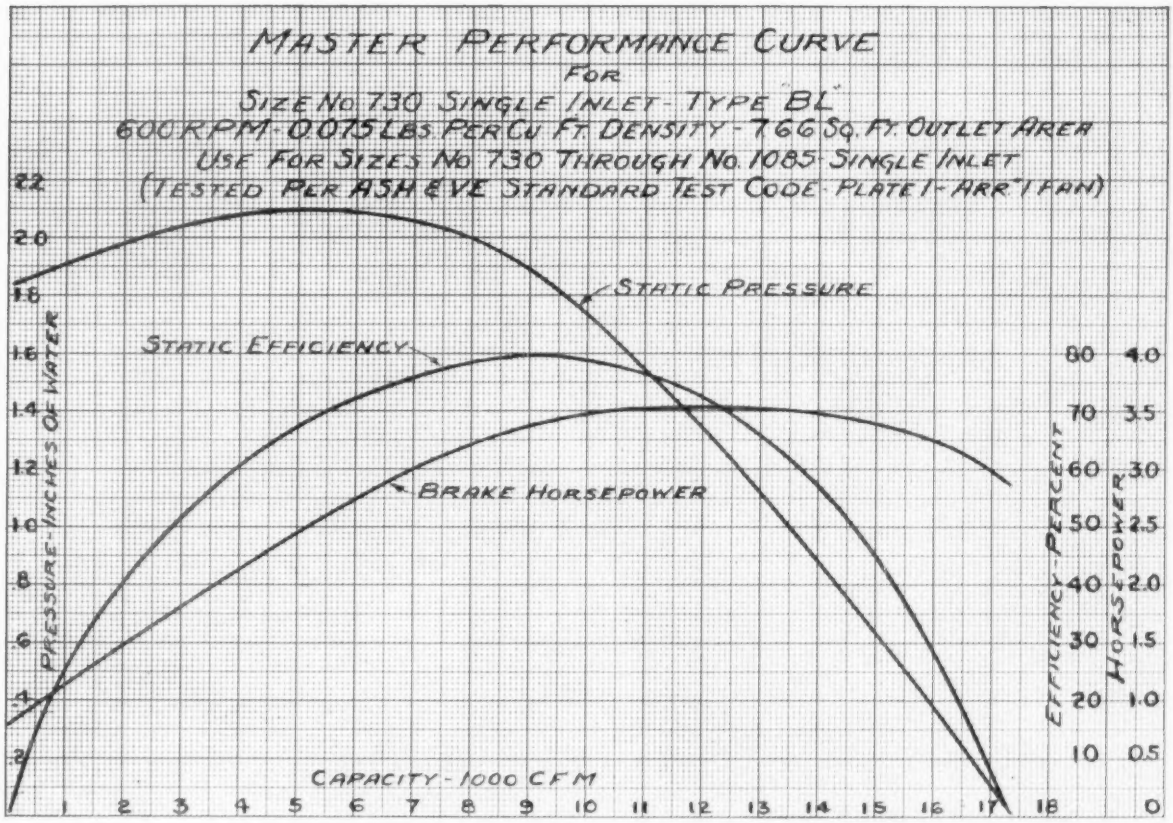
"Buffalo"

BUFFALO

BUFFALO,

Canadian Blower and Forge

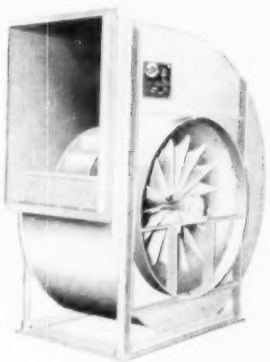
VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING


MASTER PERFORMANCE CURVE
FOR
SIZE NO. 730 SINGLE INLET - TYPE BL
600 R.P.M. - 0.075 LBS. PER CU. FT. DENSITY - 7.66 SQ. FT. OUTLET AREA
USE FOR SIZES NO. 730 THROUGH NO. 1085 SINGLE INLET
(TESTED PER ASHVE STANDARD TEST CODE - PLATE 1 - ARR'T FAN)
STATIC PRESSURE
STATIC EFFICIENCY
BRAKE HORSEPOWER
PRESSURE - INCHES OF WATER
EFFICIENCY - PERCENT
HORSEPOWER
CAPACITY - 1000 CFM

call for flexible fan performance types "BL" and "BLH" fans

"BL"—For Classes I & II Mechanical Draft Service

The "Buffalo" Type "BL" Fan will provide superior performance for most mechanical draft requirements in Classes I & II. Of non-overloading design, the "BL" insures quiet, stable output from free delivery to shutoff. The high operational efficiency of the "BL" is directly due to several unique design features. Minimum turbulence is a result of the smoothly curved inlet bell with directional guide vanes. Among other outstanding "BL" features are the correctly-designed wheel, tested and balanced at the factory to keep vibration to a minimum, and the specially shaped scroll of the "Wheel-matched" housing.



Quality which provides trouble free satisfaction and long life.

For top performance under general requirements in Classes I and II mechanical draft service, ask your nearest "Buffalo" representative about the "BL" Fan, or write today for Bulletin F-102.

FORGE COMPANY

NEW YORK

Co., Ltd., Kitchener, Ont.

FORCED DRAFT COOLING HEATING PRESSURE BLOWING

what are your needs for REMOTE LIQUID LEVEL INDICATION?

Boiler water levels and other liquid levels requiring remote indication can be handled completely by a Yarway system.

Heart of the system is the Yarway Remote Liquid Level Indicator that gives instant, accurate readings because the mechanism is operated by the boiler water or other liquid itself. The pointer mechanism is never under pressure. Clear, "wide vision" face permits easy readings from any angle.

The Yarway Indicator conforms with A.S.M.E. Boiler Code Committee ruling (Case #1155) permitting two independent remote level indicators of compensated manometric type to replace one of two required gage glasses for boiler pressures 900 psi and above.

Electronic Secondary Indicators can be added at any point in the plant. Remote Hi-Lo Alarm Signals (lights and/or horns) can be connected for additional safety.

Primary indicators fully compensated for every pressure change in boiler also available.

For permanent record of changing levels, the Yarway Hi-Lo-Graph Recorder can be furnished.

Over 12,000 Yarway Remote Indicators have already been installed. For full details, write for Yarway Bulletin WG-1824.

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
Branch Offices in Principal Cities

FULLY COMPENSATED INDICATORS

for completely accurate indication under every boiler operating condition.

ELECTRONIC SECONDARY INDICATORS

To supply additional indication at any point without pressure connections.

REMOTE SIGNALS

Hi-Lo Alarms. Lights and/or Horns.

RECORDERS

To provide permanent 24-hour record of liquid levels.

YARWAY

. . . a good way to specify remote liquid level indicators

Here are the reasons why—

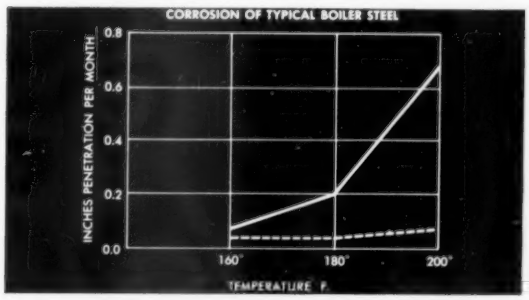
DRY-ACID CLEANERS based on Du Pont Sulfamic Acid are gaining favor in industrial equipment cleaning

SAFER TO HANDLE—Dry-acid cleaners are dustless, free-flowing powders that *handle* dry. There's no danger of spillage, spatter of liquids or broken bottles.

EASIER TO USE—No siphoning or cumbersome pouring of liquid acid—just scoop or shovel dry acid into make-up tank.

LOWER HANDLING COSTS—Packaged in convenient, easily handled and stored, disposable drums in a variety of sizes. *100-lb.* drum is more than equal to one carboy of 18° hydrochloric acid (gross weight 192 lbs.).

NO HAZARDOUS FUMES—Dry-acid compounds are non-fuming, produce no corrosive gases . . . dry *or* in solution. Special precautions necessary in handling ordinary acids are eliminated.



_____ *Inhibited hydrochloric (5% HCl, by weight)*
- - - - - - *Inhibited Sulfamic Acid (7% by weight)*

LESS CORROSIVE—Cleaners based on Du Pont Sulfamic Acid form solutions equal to hydrochloric acid in penetrating power, yet are far less corrosive (as shown by graph above).

Cleaners based on Du Pont Sulfamic Acid are ideal for removing hard-water scale and other mineral deposits from industrial equipment such as air conditioning and ice-making units, food-processing vessels, steam boilers, milk evaporators and pasteurizers, marine evaporators and heat exchangers.

We'll gladly send you additional information on sulfamic-acid-based cleaners and the names of formulators who offer these cleaning compounds. E. I. du Pont de Nemours & Co. (Inc.), Grasselli Chemicals Dept., Room N-2533, Wilmington 98, Del.

E. I. du Pont de Nemours & Co. (Inc.)
Grasselli Chemicals Dept., Rm. N-2533
Wilmington 98, Delaware

Please send me ( ) free booklet about dry-acid cleaners based on Du Pont Sulfamic Acid. ( ) Names of formulators who offer these cleaning compounds.

*Name*_____

*Firm*_____ *Title*_____

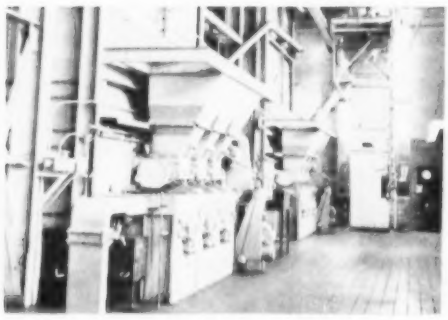
*Address*_____

*City*_____ *State*_____

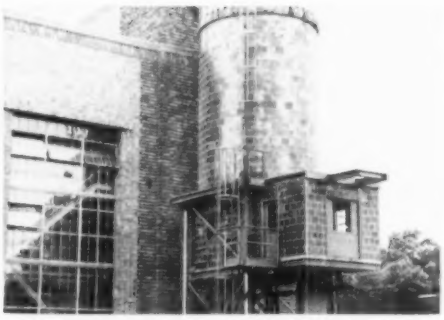
DU PONT **SULFAMIC ACID**

REG. U.S. PAT. OFF.

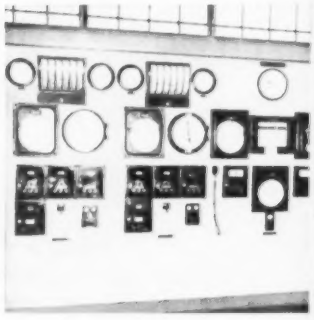
BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



Firing aisle shows both Union Iron Works boilers . . . identical 2-drum, bent-tube type with a normal rating of 70,000 lb/hr. These units are fired by Detroit Rotograte Spreader Stokers.



Furnace ash and dust from Prat-Daniel Collectors are conveyed pneumatically to this 50-ton ash storage silo. Rotary dustless unloader assures a clean operation. Ash handling system is by United Conveyor Corp.



Combustion controls and instruments — centered in this control panel by Hays Corporation — regulate combustion and auxiliary operations automatically.

Coal scores with Notre Dame

University power plant burns coal for modern steam generation

Enrollment growth and building expansion had put a strain on the power plant at the University of Notre Dame, South Bend, Ind. After careful study—by the consulting firm of Albert Kahn Associated Architects and Engineers, of Detroit—a decision was made to modernize steam facilities and add power generating equipment. Two new coal-fired boilers, a turbo-generator and auxiliary equipment were installed.

Maximum efficiency is achieved through automatic combustion control and complete instrumentation. Today steam is generated *economically.* Another noteworthy result of these innovations has been the *cleanliness* of operation . . . making Notre Dame's power plant a model of good housekeeping.

Coal is lowest-cost fuel

Today, *when the annual cost of fuel often equals the original cost of the boilers,* you should know that bituminous coal is the lowest-cost fuel in most industrial areas. And modern coal-burning equipment gives you 15% to 50% *more* steam per dollar, while automatic operation trims labor costs and eliminates smoke problems. What's more, tremendous coal reserves and mechanized mining procedures assure you a constantly plentiful supply of coal at stable prices.

Consult an engineering firm

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel costs and equipment—can effect great savings for you with the efficiency and economy of coal.

Technical advisory service

To help you with fuel problems, the Bituminous Coal Institute offers a free technical advisory service. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to address below or send coupon. Ask also for case histories booklet, complete with data sheets. You'll find them informative.

BITUMINOUS COAL INSTITUTE

Department C-12, Southern Building, Washington 5, D. C.

Exterior view of Notre Dame power plant. Careful planning of design combines spacious interior and pleasing exterior lines to maintain campus beauty.

SEND COUPON FOR NEW "Guide Specifications for Underfeed Stoker Fired Low-Pressure Heating Plants." Heavy demand for the first edition of this booklet, adaptable for design loads 3,000 to 26,000 EDR steam, has justified an expanded edition covering application of underfeed stokers to firetube, watertube and sectional cast iron boilers. Complete specifications criteria cover all aspects of typical heating plant.

BITUMINOUS COAL INSTITUTE, Southern Bldg., Washington 5, D. C. C-12

Gentlemen: Please send me:

☐ Guide Specifications Booklet ☐ Case histories on larger plants

☐ I am interested in your advisory service

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

COMPLETE LINES OF WALWORTH VALVES for POWER PLANT SERVICE

Featuring Walworth Pressure-Seal Valves

Here are cast steel valves built for high-pressure, high-temperature service. The unique bonnet-to-body design utilizes internal line pressure for a tight, leakproof connection. The higher the pressure the tighter the bonnet joint! Bulky, heavy bonnet flanges, bonnet studs, and nuts are completely eliminated providing a modern valve design of truly streamlined proportions. Maintenance is simplified as Walworth Pressure-Seal Valves are easily assembled, disassembled, and insulated.

Walworth Pressure-Seal Valves are available in 600, 900, 1500 and 2500 Lb ratings, ASA B16.5 – 1957, and in a wide range of sizes and types. Complete information is available from your nearby Walworth Distributor – or – write Walworth for a free copy of Circular 16.

and including these valves for "*'round-the-plant*" use!

WALWORTH SMALL CAST STEEL Y-GLOBE VALVES. Simplified design eliminates many of the problems encountered in high-temperature, high-pressure service. No bonnet joint. Improved back-seat design means longer life for packing rings.

WALWORTH LUBRICATED PLUG VALVES. Easy turning—quick operating. Lubricant can be renewed while the valve is in service. Lubricant completely surrounds the plug ports for a tight seal against leaks. Remember, always use Walworth Lubricant in Walworth Lubricated Plug Valves.

WALWORTH BRONZE VALVES. Standardized lines of bronze valves provide an unsurpassed system of interchangeability of parts, drastically reducing inventory problems. Walseal Valves with brazing ends also available in a variety of types.

WALWORTH IRON BODY GATE VALVES. Straight-flow port design reduces fluid turbulence to a practical minimum. Seat rings of end-seated type are screwed into the body. Brass liner on glands assures greater resistance to corrosion and scoring. Available with threaded or flanged ends.

WALWORTH CAST STEEL GATE VALVES. Bolted bonnet, wedge gate, OS&Y. Bonnets and bodies are engineered to withstand pressure and minimize distortion. Heavy steel walls provide extra strength and longer life. Deep stuffing boxes in all sizes (2" to 24") insure tightness and maximum packing life. Also available in globe and angle types.

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Warmest Wishes for a Merry Christmas

EASTERN GAS AND FUEL ASSOCIATES

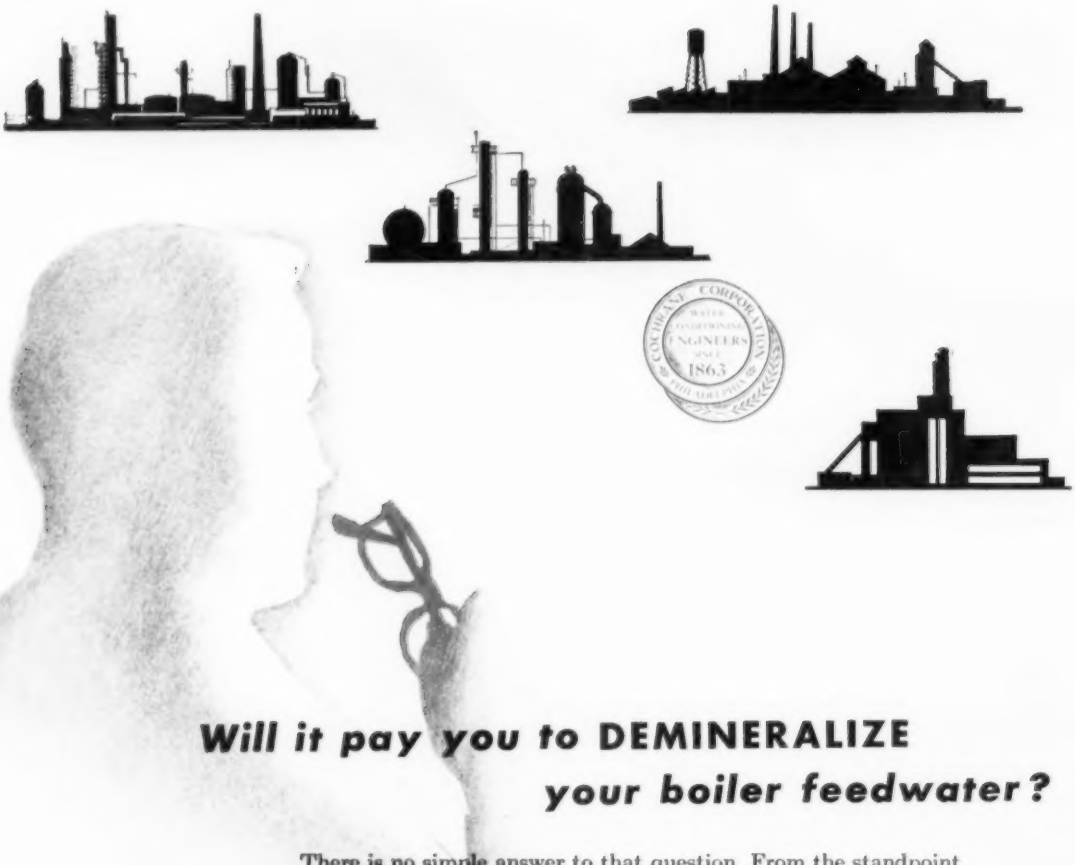
BEACON COAL

EASTERN GAS AND FUEL ASSOCIATES

PITTSBURGH BOSTON CLEVELAND DETROIT NEW YORK NORFOLK PHILADELPHIA SYRACUSE

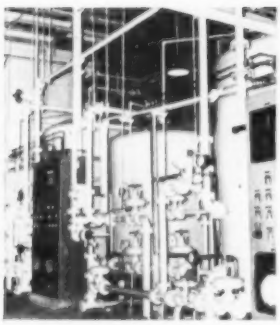
For New England: New England Coal & Coke Co. *For Export:* Castner, Curran & Bullitt, Inc.

Progress in water conditioning . . .



Will it pay you to DEMINERALIZE *your boiler feedwater?*

There is no simple answer to that question. From the standpoint of water quality, the superiority of demineralization is unquestioned. It removes dissolved solids, including silica more completely than any other treatment method and is a "must" for high pressure boiler systems. But in some cases the installation and operating cost of a demineralizing system may not be economically justified. Instead, another type water treating system may be advisable, particularly for boilers in the medium pressure range of 750 to 1250 psig.



As we said, there is no simple answer. But there *is* an easy way to find the answer: Present your problem to Cochrane water treatment specialists. They have designed water treatment systems for industrial plants and utilities with makeup feedwater requirements as high as 8000 gallons per minute! This background and experience in all phases of the art is your guarantee of an expert, impartial analysis and recommendation because, Cochrane engineers and manufactures every type of water conditioning system.

To find out whether or not demineralization is the answer to your feedwater treatment problem write: Water Treatment Division.

Ask for a copy of the Demineralizer Handbook.

Cochrane CORPORATION

3109 N. 17th Street, Philadelphia 32, Pa.

Philadelphia • New York • Chicago

Cochrane Water Conditioning, Limited, Toronto, Montreal, Winnipeg, Canada.

Representatives in thirty-two principal cities in U.S., Hawaii, Puerto Rico; also Havana, Cuba; Paris, France; La Spezia, Italy; Mexico City, Mexico; Caracas, Venezuela; Santiago, Chile; Manila, Philippine Islands.

POTTSTOWN METAL PRODUCTS DIVISION—
Custom built carbon steel and alloy products.

Demineralizers • Zeolite Softeners • Hot Process Softeners • Hot Lime Zeolite Softeners • Dealkalizers • Reactors • Deaerators • Pressure Filters
Continuous Blowoff Systems • Condensate Return Systems • Steam Specialties

BERGEN GETS 8 LJUNGSTROMS® ...AND SOME REMARKABLE CUSTOMER SERVICE

Public Service's new Bergen Generating Station will be served by 8 large, horizontal Ljungstroms. Almost as important . . . the Ljungstroms will be serviced *throughout* their life by Air Preheater.

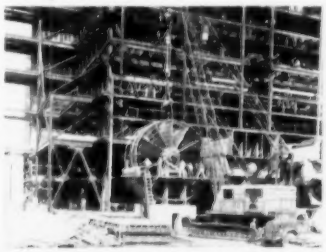
What's special about this customer service? For one thing, it's the considerable knowledge and talents of Air Preheater's engineers. They have been involved in nearly every conceivable type of boiler/preheater problem. They've seen how these problems can be handled. And they can put this experience to work for operators of Ljungstrom air preheaters.

Your Air Preheater engineer also makes regular calls to check the operation of every Ljungstrom – for as long as it's in service. (This now includes installations dating back to 1923.)

So, when you select a Ljungstrom, you're never entirely on your own. You *continue* to be the responsibility of a competent Ljungstrom engineer and benefit from his experience and knowledge. Maybe that's why 9 out of 10 preheaters sold are Ljungstroms.

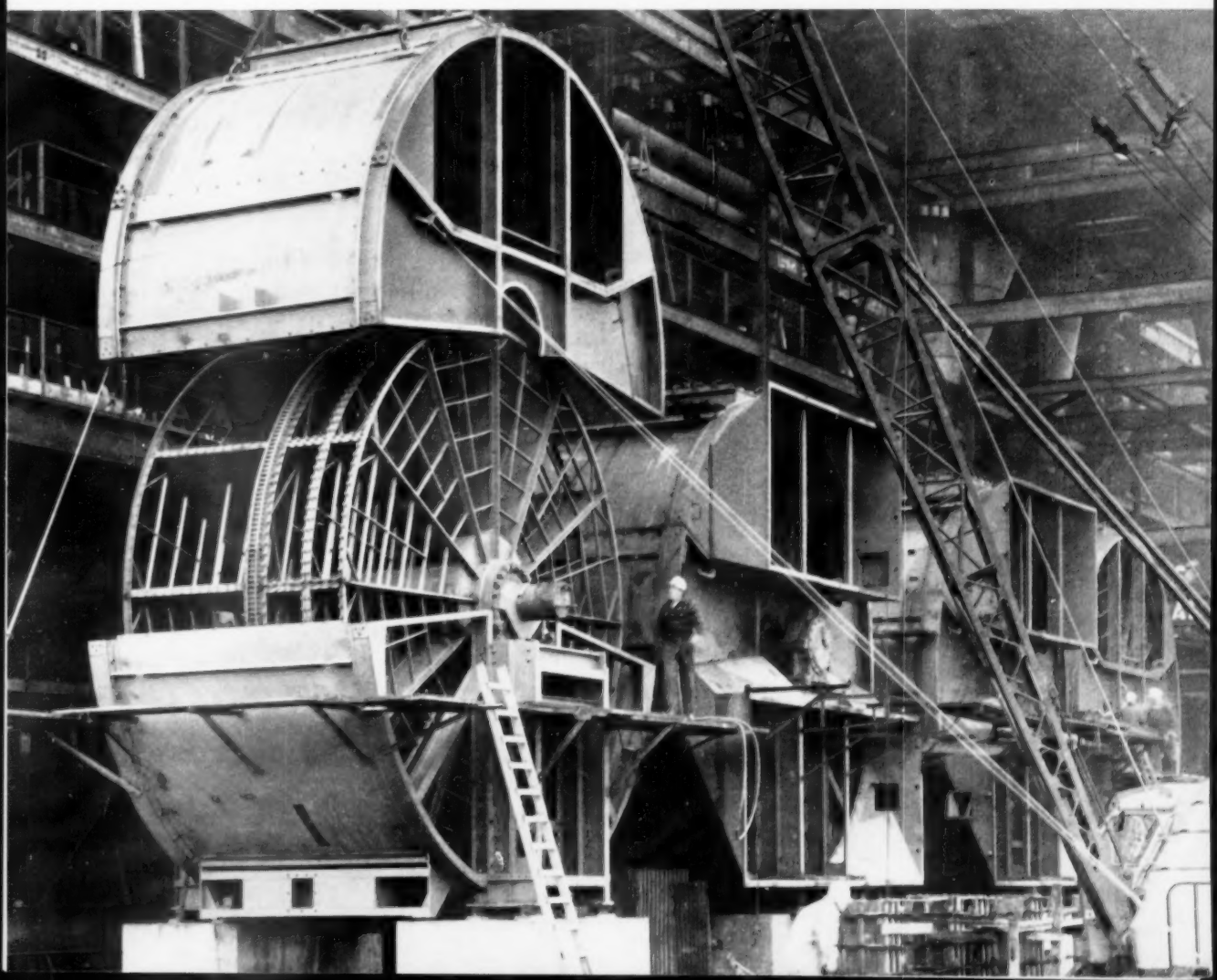
Thirty-five tons of Ljungstrom rotor being lowered into place at the new Bergen Generating Station at Ridgefield, N. J. (When the heating elements are installed the rotor will weigh 150 tons.) This is one of eight preheaters being installed by Public Service Electric and Gas Co. to serve two boilers – each evaporating 1,900,000 lbs of steam /hr. The first boiler is to be fired early next year. Anticipated preheater outlet temperature is about 275 F.

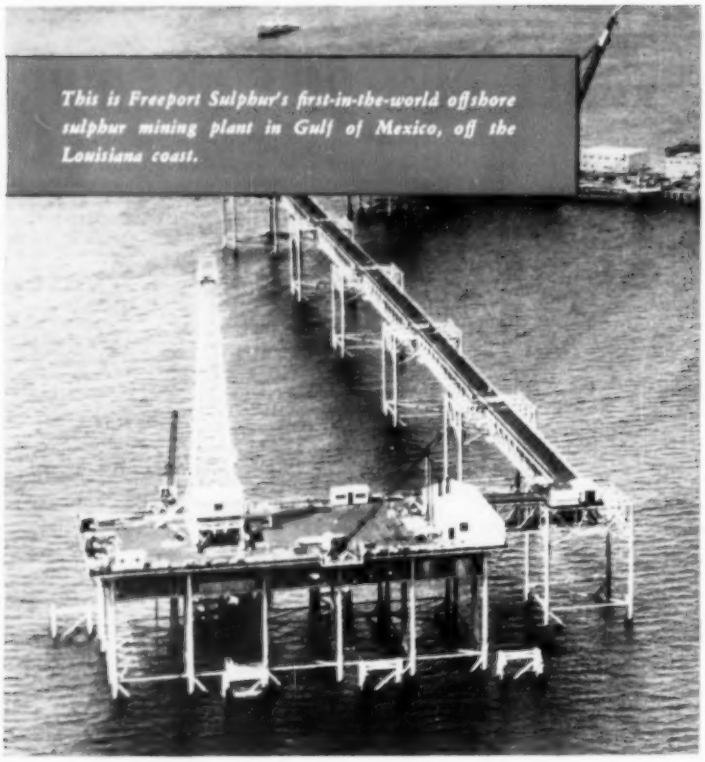
Public Service is one of the first Northern utilities to use large-size horizontal preheaters. They have nine such horizontals in operation at their Linden Generating Station and have ordered eight more for their new Mercer Generating Station.



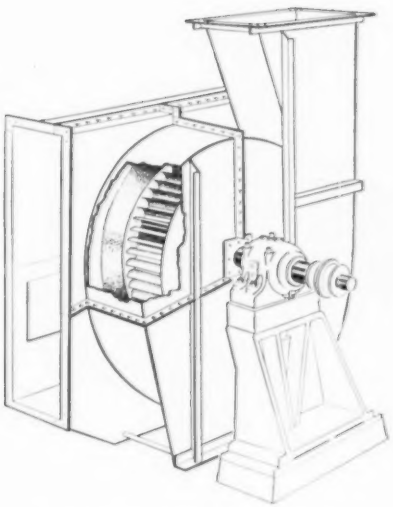
THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.





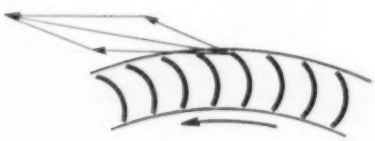
This is Freeport Sulphur's first-in-the-world offshore sulphur mining plant in Gulf of Mexico, off the Louisiana coast.



This is Green's MC type fan, 4 of which were supplied to Freeport Sulphur—each with 54" wheel, producing 67,800 CFM against 18" S.P. at 715°.

FREEPORT SULPHUR'S doing it for the first time in the world!

and Green MC type fans will help this gigantic air lift!



It's the forward curve at BOTH tip and heel of fan blades that does the job on Green MC type fans.

Freeport Sulphur had a tough engineering problem.

For their world's first offshore sulphur mining operation, Freeport Sulphur has to compress truly tremendous air volume to air lift liquid sulphur to the surface. Fans are needed for the steam operating unit compressing this air.

Rugged, dependable fans are required. Also, fans that need but a minimum of working space.

Where did Freeport Sulphur get such fans?

Easy — they ordered Green MC type fans. These fans are not only rugged, but the MC is the smallest fan that can be used to perform any required job.

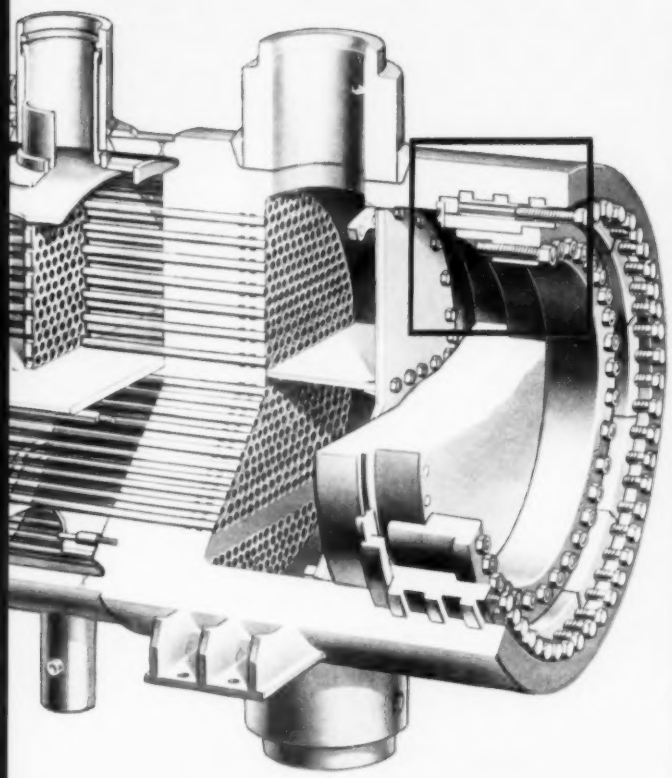
You, too, might solve a vexing engineering problem by calling on Green.

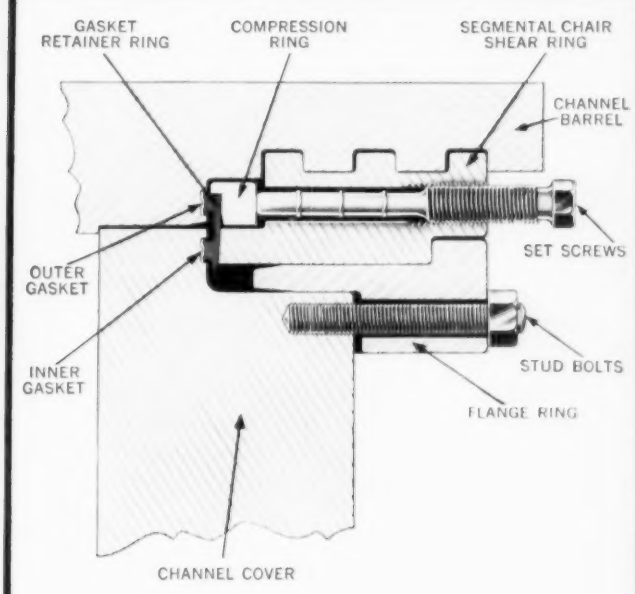
Green

THE GREEN FUEL ECONOMIZER CO., INC.,

BEACON 3, NEW YORK

ALCO FEEDWATER HEATERS





Detail of Type "D" closure on ALCO high-pressure feedwater heater shows simplicity of dismounting and reassembly, isolation from contained condensate.

TWO MILLION HOURS OF OPERATION PROVE ALCO'S TROUBLE-FREE CLOSURE

The ALCO Type "D" closure, standard on all ALCO high-pressure feedwater heaters, has now rolled up more than two million hours of operation in power plants. During this time, the positive mechanical-locking design of the closure has turned in an outstanding record of trouble-free performance.

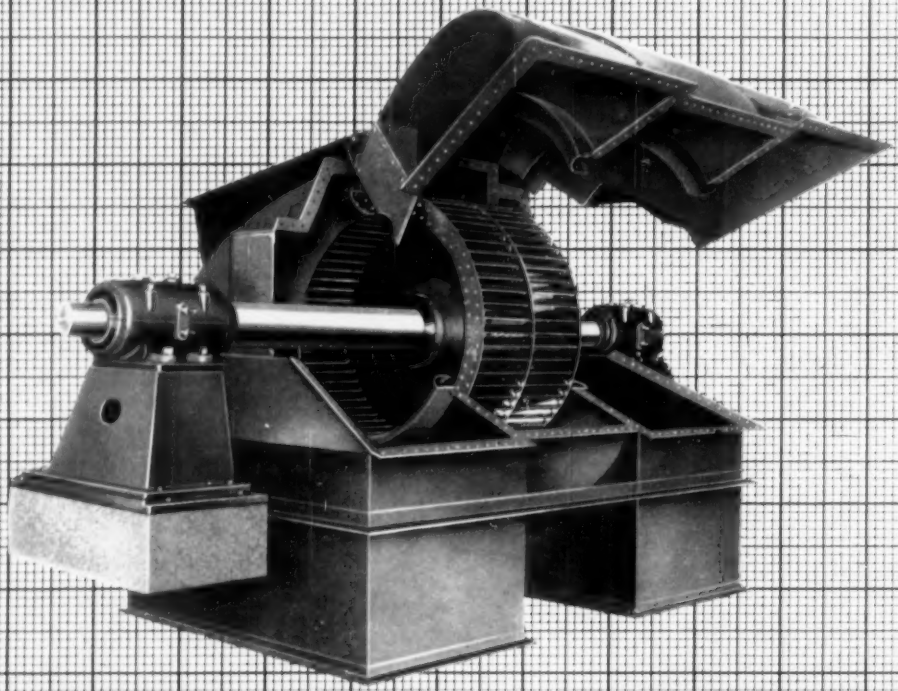
In addition, the ALCO Type "D" closure provides many other important operational advantages. The closure's locking strength is uniform. Screwed fastenings and locking devices are dry and cannot be corroded by condensate. If maintenance of tubes is necessary, the closure is easily demounted with hand tools for full access to tube ends. Reassembly is quickly accomplished with the same hand tools. For added savings, no costly and time-consuming pressure welding is necessary.

Specialists in any ALCO sales office will be happy to discuss with you in detail the design, construction and many advantages of the ALCO Type "D" closure on feedwater heaters. For an informative brochure, write ALCO Products, Inc., Dept. 135, Schenectady 5, New York.

ALCO **ALCO PRODUCTS, INC.**
NEW YORK
SALES OFFICES IN PRINCIPAL CITIES

Locomotives · Diesel Engines · Nuclear Reactors · Heat Exchangers · Springs · Steel Pipe · Forgings · Weldments · Oil-Field Equipment

AMERICAN BLOWER SIROCCO FANS



HIGH STATIC EFFICIENCY
LOW INITIAL COST
SMALL FLOOR SPACE

LOW RPM
LONGER LIFE
LOW WR²

INDUCED AND FORCED DRAFT FOR BALANCED DRAFT OR PRESSURIZED BOILERS • DOUBLE AND SINGLE INLET

Look for low initial cost, reduced operating costs, guaranteed performance ratings, minimum maintenance and space requirements. You'll find them *all* in American Blower Sirocco mechanical draft fans.

Specially designed for induced-draft and forced-draft work, Sirocco Fans feature die-formed, forwardly inclined blades for high static efficiency at low rpm's. Streamline, low-turbulence inlets also contribute to high efficiency. And for longer service life, Sirocco Fans have heavy-duty rim and hub plate construction . . . heavy, steel-plate housings and inlets. Special erosion-resistant features are available, as well.

For high efficiency, low cost over the entire operating range, couple Sirocco Fans with American Blower *Gyrol*® Fluid Drive. Infinitely variable in speed, Gyrol Fluid Drive matches fan speed to boiler demand; pays off in longer life for fan wheels and bearings; quieter operation.

If you are investigating mechanical-draft equipment for new or existing installations, take advantage of our experience in air handling. Call your nearby American Blower branch office, today. Or write: American-Standard,* American Blower Division, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
AMERICAN BLOWER DIVISION

Hall Industrial Water Report

VOLUME 6 DECEMBER 1958 NUMBER 6

From Kerosene to 100 Octane

The cat crackers of today's oil refineries bear little resemblance to the batch stills of yesteryear. But the old and the new do have one thing in common—water problems. Treatment of water for boilers has become more critical because of higher pressures and ratings and greater necessity for avoiding interruptions in production. The same is true of service and cooling water treatment. And waste water problems are becoming more acute because of the pressure to conserve water and clean up our lakes and rivers.

Hall Laboratories engineers have been working with water in refineries as well as in other industries for more than thirty years. They are ready to help you with all your water problems.

Sweetening Sour Water

Deposits formed so rapidly in the sour water deodorizing tower at a Canadian oil refinery that chemical cleaning was required every month. Each cleaning job cost $600.

When he learned of the problem, Hall engineer J. S. Sullivan recommended the use of Calgon and Hagan Dispersive. The cost of these chemicals would be only a fraction of the cost of chemical cleaning.

After treatment was started the tower operated without any indication of deposit formation and inspection was postponed for three months. When the tower was inspected, Sullivan and the operating men were gratified to find it clean.

Failure in Sixteen Days

A Northwestern oil refinery installed two boilers, and a hot process lime-soda softener to treat the hard, high solids feedwater. Operation was started without phosphate conditioning of the boiler water and sixteen days later one boiler was out of service with ruptured tubes as a result of scale formation.

In response to the call for help a Hall engineer left for the plant immediately. He found that plant operation depended upon keeping the remaining boiler in service. This seemed doubtful because a peek into the furnace revealed overheated spots on many tubes, a literal red light warning of insulating scale within them.

There was no time to start with a low phosphate feed and to gradually build it up so as to avoid rapid loosening of scale and possible tube blockage. Full phosphate conditioning was started at once. Then the Hall engineer had to sweat it out. Would there be tube trouble? Would carryover occur because of high concentrations? Fortunately, neither occurred. Within 24 hours the overheated spots disappeared and everyone relaxed.

Without proper conditioning of the boiler water, tubes failed in sixteen days. Following the establishment of desirable conditions many years passed without further difficulty.

Saving by Wasting

A petrochemical plant used well water for cooling in once-through services which required colder water than the cooling tower could deliver. Practically all of the well water was then discharged to the cooling tower system as make-up. Since this was far more water than was actually required for make-up, the amount of blowdown from the recirculating cooling system was about four times what it should have been.

Treatment of the recirculating cooling water for corrosion control involved the use of sulphuric acid, Calgon® and Coraid.® Hall engineer S. R. Osborne pointed out that the excessive blowdown was resulting in the wastage of large amounts of chemicals—more than $60.00 worth a day. He recommended that this be saved by discharging to the sewer all of the well water not actually required for make-up to the recirculating cooling system.

In most plants Hall engineers are looking for ways to save money by reusing or recovering cooling and waste water. In this case the plant could save about $22,000 annually by wasting rather than recovering once-through cooling water.

Pitted Gauge Glasses

A very common problem often puzzling to boiler operators is the internal wastage of glass above the water level in gauge glasses. Water level visibility is impaired and sometimes the glasses are weakened to the point of failure.

When this problem was first referred to Hall Laboratories years ago, study by the Hall research staff revealed an interesting process of corrosion.

Steam is continually condensing on gauge glasses above the water level. The hot, pure water slowly dissolves the glass. Sometimes dissolved silica reprecipitates as an opaque deposit which imparts a frosted appearance to the glass.

There is no way to modify boiler water treatment to prevent or control the trouble. When flat or prismatic glasses are affected replace them with mica-backed flat glasses. When tubular glasses are involved, try to obtain a more resistant glass.

Free Copies of Water Lecture Available

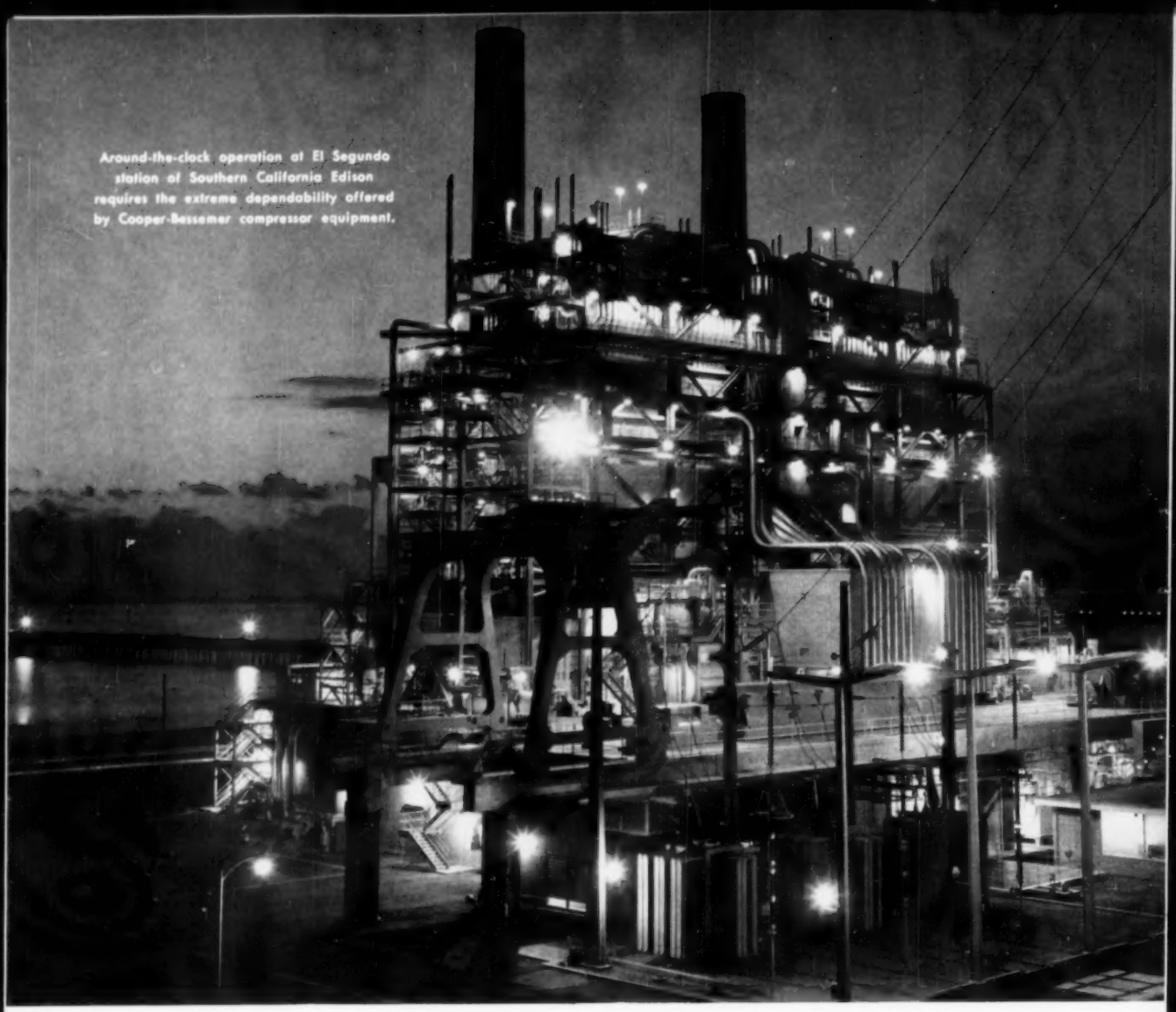
A limited number of free copies of "Your Most Important Raw Material," the Edgar Marburg Lecture by Dr. Everett P. Partridge, are now available. For your copy or for information on how the Hall System can help solve your particular water problems, write, wire or call address below.

Water is your industry's most important raw material. Use it wisely.

HALL LABORATORIES

HAGAN

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water



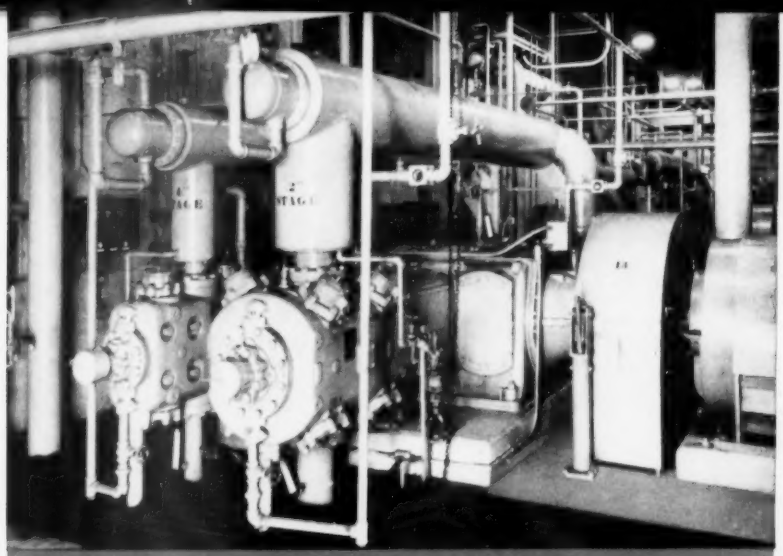
Around-the-clock operation at El Segundo station of Southern California Edison requires the extreme dependability offered by Cooper-Bessemer compressor equipment.

Increase boiler capacity,

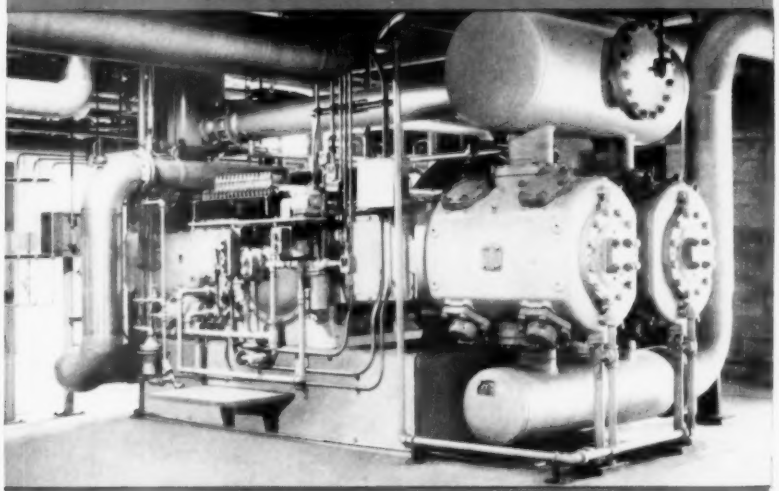
...with Cooper-Bessemer air Compressors for soot blowing service

Steam stations everywhere profit from multi-stage Cooper-Bessemer M-Line air compressors used to clean slag and ash deposits from boiler unit surfaces. For example, four steam stations of Southern California Edison Company, the Sayreville station of Jersey Central Power & Light Company, the Breed Plant No. 1 of Indiana and Michigan Electric Company, and the Philip Sporn Plant Unit No. 5 of the Ohio Power Company . . . *all* depend on the experience and efficiency offered by Cooper-Bessemer.

You'll find air cleaning with Cooper-Bessemer equipment the most effective and economical answer to a continuing problem. Automatic regulation, heavy-duty con-

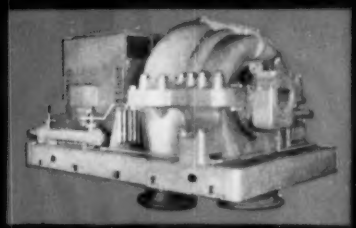


Extreme accessibility is another plus feature of motor-driven FM compressors in the Sayreville station of Jersey Central Power & Light.

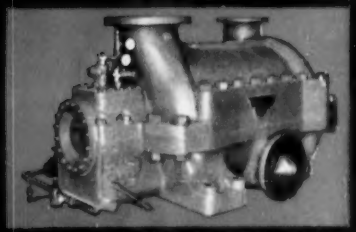


This compact Cooper-Bessemer FM compressor, rated 300 hp at 400 rpm, cuts trouble and costs at the El Segundo steam-electric generating station.

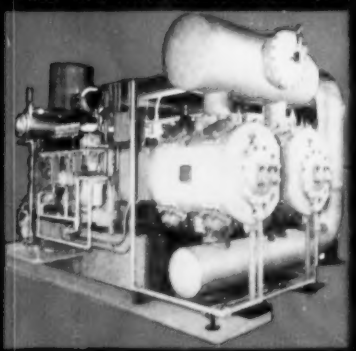
TO MEET SEVERE SERVICE REQUIREMENTS



Direct motor-driven multi-stage centrifugal compressors for sizes from 3000 cfm free air and up.



Multi-stage centrifugal compressors for sizes from 7000 cfm free air and up.



Multi-stage reciprocating compressors for up to 30,000 cfm free air.

availability and efficiency

struction and a range of horsepower sizes offer you the ideal unit.

For your next steam generating unit, check with Cooper-Bessemer for the latest in soot blowing services. Sizes are available up to 10,000 hp in both reciprocating and centrifugal designs. Write for additional information.

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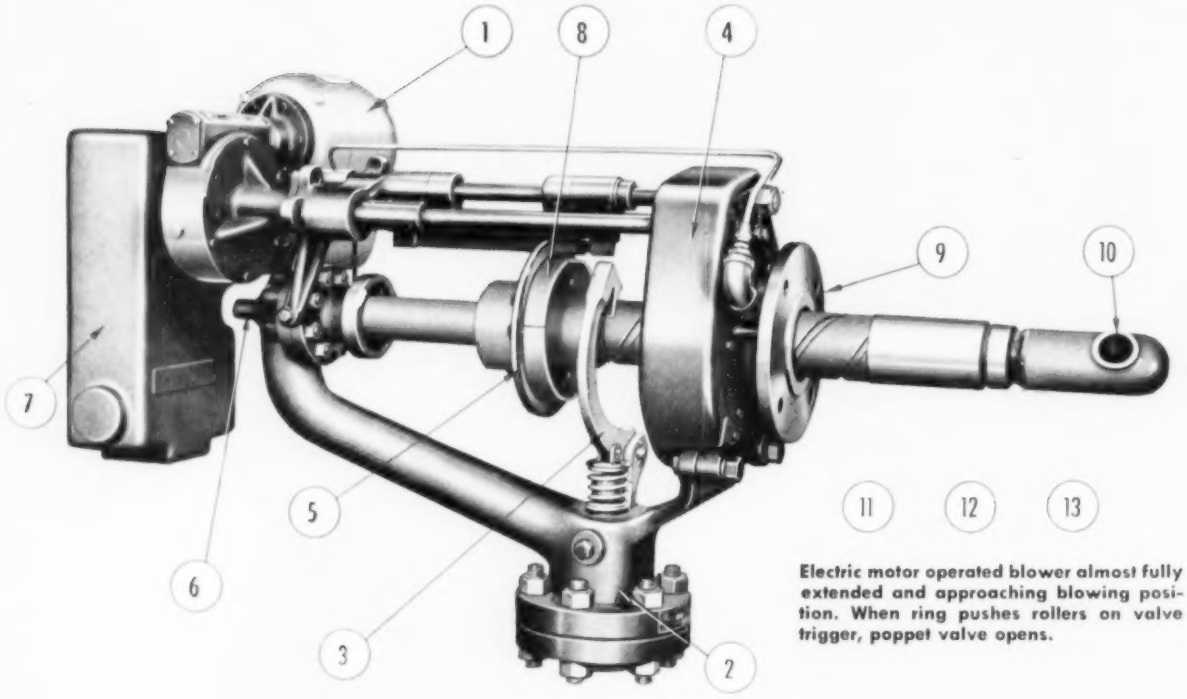
ENGINES: GAS · DIESEL · GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

For BETTER Boiler Cleaning



Electric motor operated blower almost fully extended and approaching blowing position. When ring pushes rollers on valve trigger, poppet valve opens.

(1) Single motor (electric or air) both rotates and propels the nozzle

(2) New high-flow poppet type valve assures tight seating without critical adjustment, has welded-in seat with stellited surfaces available.

(3) Positive mechanical action of valve without pilot or diaphragm actuation

(4) Positive mechanical drive through gears for all operations

(5) Valve can open only when nozzle is in blowing position

(6) Adjustable control for individual unit blowing pressure . . . no orifice required in line

(7) Simple, reliable control for local or remote push button operation . . . easily adapted to automatic sequential operation (either air or electric)

(8) Blowing arc easily adjusted for position and extent (up to and including 360°)

(9) Simple mounting on all types of wall construction. No other external support needed. Can mount in any position permitting piping drainage

(10) Improved blower nozzle provides more *available* cleaning energy per pound of steam or compressed air

(11) Completely automatic from start to finish

(12) Suitable for outdoor use without protection except under very severe ice conditions

(13) All operating parts readily accessible for easy maintenance

at LOWER COST

IMPROVED Diamond MODEL IR BLOWERS

(SHORT RETRACTING LANCE TYPE)

This improved Diamond Model IR Blower does a better job of cleaning water cooled furnace walls, hopper slopes or narrow portions of tube banks adjacent to walls. The retracting feature enables it to operate in zones of extremely high gas temperature; it will remove all dust and most slag deposits over a wide radius from the nozzle.

Cleaning furnace wall tubes effectively reduces gas temperatures leaving the furnace . . . improves overall efficiency of tube bank cleaning. Also, furnace wall cleaning contributes substantially to control of superheat and reheat-steam temperatures on high-duty units.

Check the features listed on the left-hand page. For additional information on the improved Model IR, ask your local Diamond office or write directly to Lancaster for a copy of Bulletin 1079V.

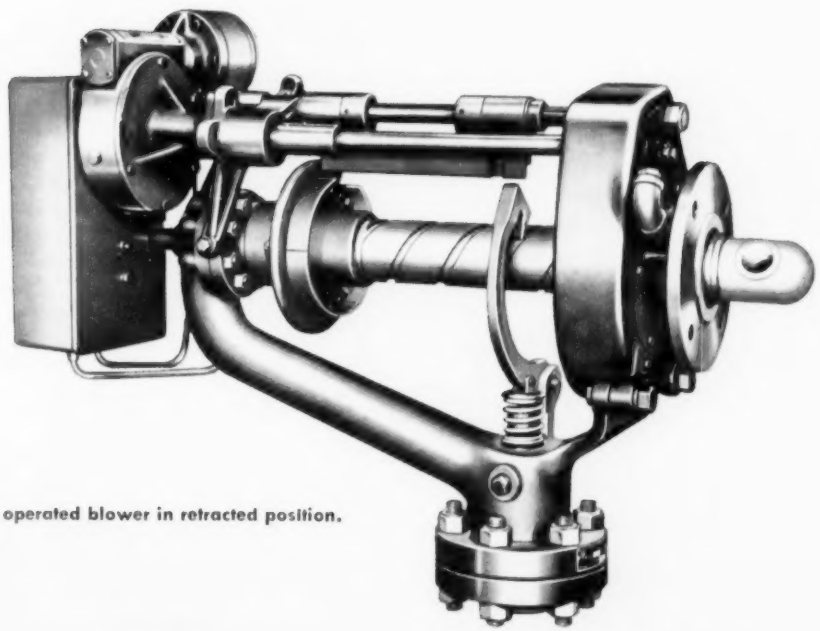
Diamond

DIAMOND POWER SPECIALTY CORP.

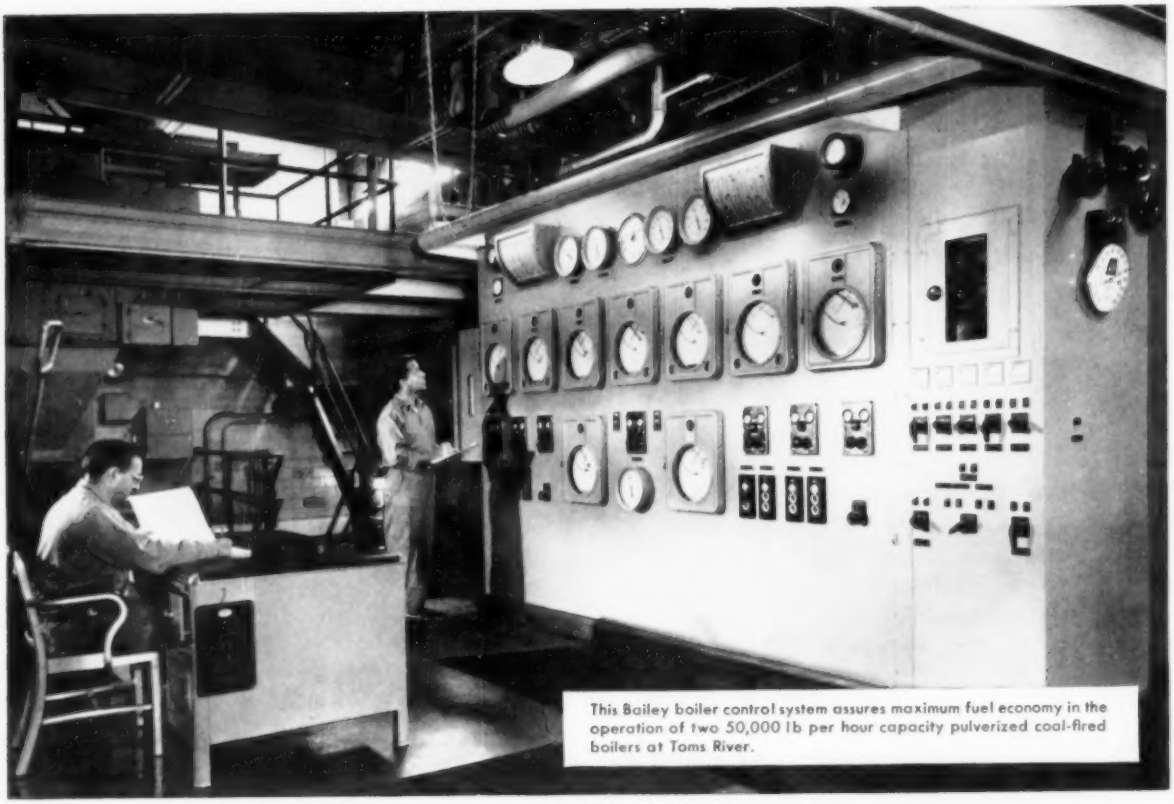
LANCASTER, OHIO

Diamond Specialty Limited, Windsor, Ontario

7949A



Air motor operated blower in retracted position.



This Bailey boiler control system assures maximum fuel economy in the operation of two 50,000 lb per hour capacity pulverized coal-fired boilers at Toms River.

How Bailey helps control STEAM COSTS AT TOMS RIVER

With a Bailey-engineered control system you can count on a high output of available energy per unit of fuel, whether you operate a small industrial boiler or a large central station boiler.

They did at Toms River — Cincinnati Chemical Corporation's plant in Toms River, N. J.! Bailey Controls help them save fuel by continuously maintaining desired operating conditions.

Most high-efficiency steam generating plants rely on Bailey because:

1. A Complete Line of Equipment

Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems in measurement, combustion and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work more efficiently for more than forty years. Veteran engineer and young engineer alike, the men who represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering counsel on your steam plant control problems.

A139-1

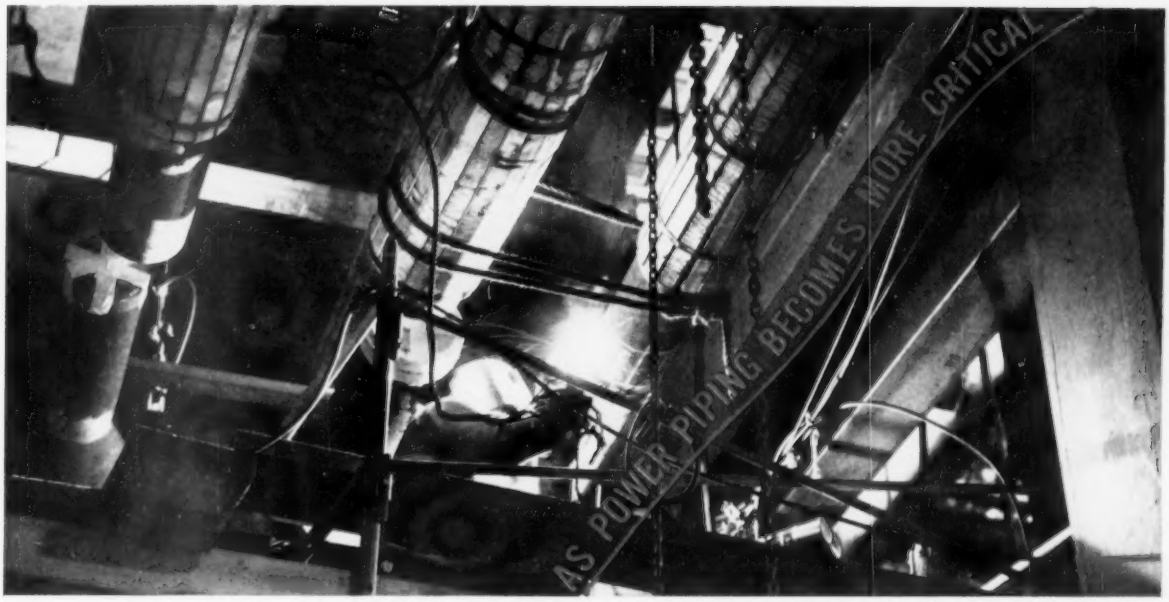
Instruments and controls for power and process

BAILEY METER COMPANY

1025 IVANHOE ROAD • CLEVELAND 10, OHIO

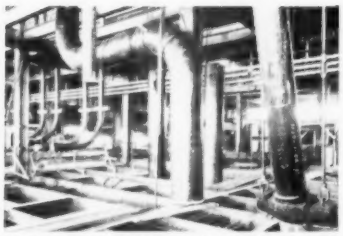
In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

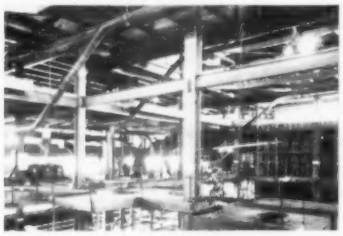


A main steam line is K-Welded to the mixing header. There are eight main steam lines to this header from the boiler, and four from mixing header to turbine. With inside diameters up to 4.938 in. and minimum wall thicknesses as much as 2.860 in., sections weigh four to five tons. Main steam header weighs over ten tons.

KELLOGG'S FIELD WELDING KEEPS PACE



Section of second cold reheat system (center) in process of being positioned, with section of first cold reheat system (right) partially in place. Four boiler feed risers at left.

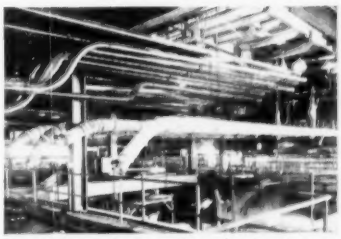


General view inside Eddystone Station, eleven floors high, showing high pressure boiler feed water risers (top and center) as these were being erected by Kellogg.

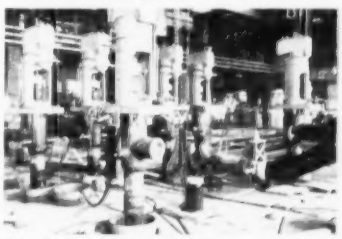
During erection of Philadelphia Electric Company's Eddystone Station, Unit No. 1, *eighty* K-Welds* . . . Kellogg's inert gas shielded technique of manual arc welding . . . will be made by Kellogg on the Type 316 stainless main steam lines alone. Following Kellogg's shop fabrication procedures on this job, every K-Weld will be given a total of *four* inspections by liquid penetrant and radiography during welding and after heat treatment.

Time required to finish and inspect each weld completely on this supercritical, heavy-walled piping is *eight to ten working days*. Further evidence of the magnitude and complexity of Kellogg's erection and welding assignment is provided by these construction photographs.

Kellogg welcomes inquiries on its complete service to the power piping industry from consulting engineers, engineers of power generating companies, and manufacturers of boilers, turbines, and allied equipment.



Four of the main steam lines, showing the protective wood lagging installed at Kellogg plant. This is not removed, except at welding points, until insulation is applied.



Six of the eight special high pressure valves being installed by Kellogg at the Eddystone Station—Philadelphia Electric Company's new supercritical steam power plant.

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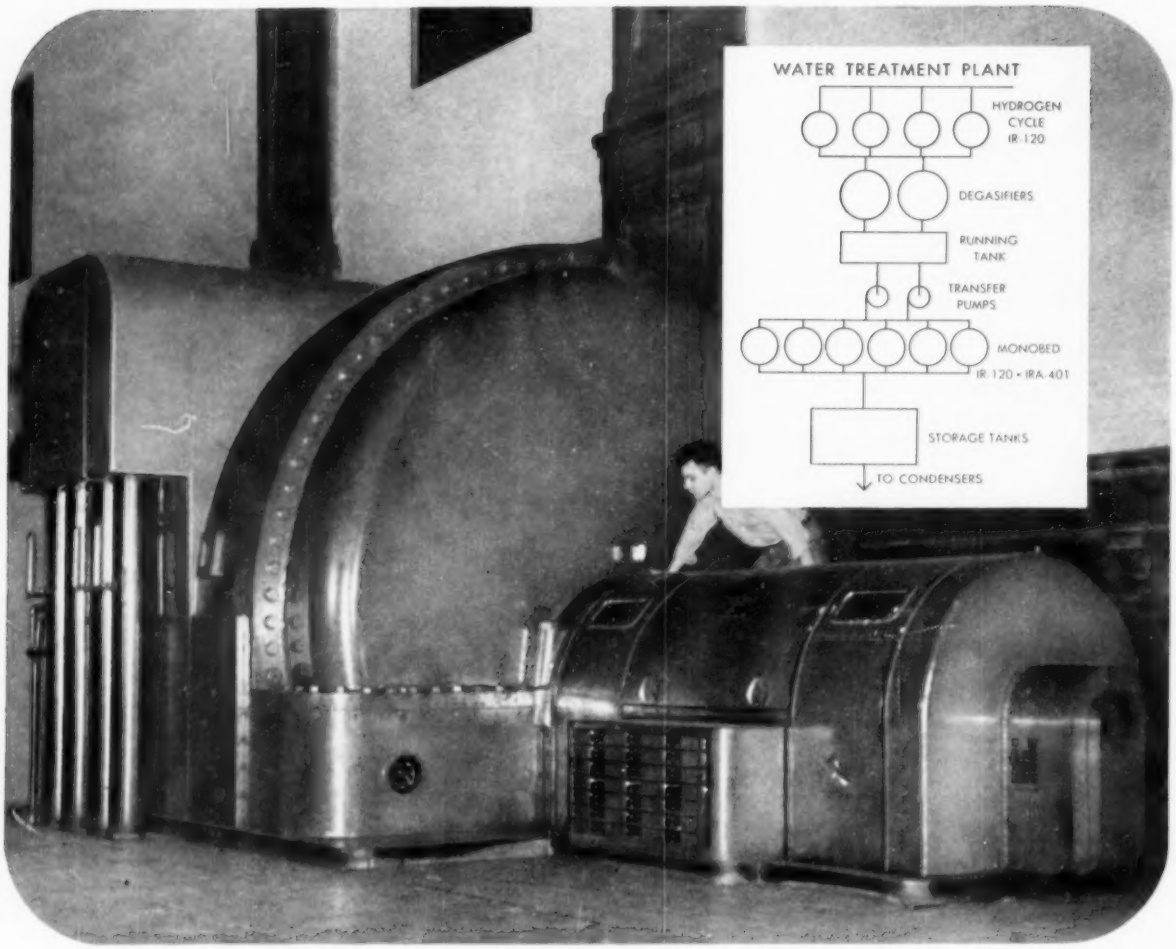
ION EXCHANGE RESINS for high pressure boiler feed



Make-up requirements run as high as 2,500,000 pounds per hour at this Consolidated Edison power plant, Waterside, New York.

"Over 45,000,000,000 pounds of low mineral and low silica content water produced—blow-down reduced—turbine blade fouling overcome"

This is the impressive record of the AMBERLITE ion exchange resin installed in 1954 at Consolidated Edison's Waterside station in New York. The water supply for this power generating station passes first through 4 beds of AMBERLITE IR-120 cation exchange resin operating in parallel in the hydrogen cycle, then through 6 MONOBED units in parallel (using one-third AMBERLITE IR-120 and two-thirds AMBERLITE IRA-401 anion exchanger) to provide a deionized water supply of extremely low mineral content. The MONOBED units have now gone through over 3,000 regeneration cycles.

This is but one of many AMBERLITE ion exchange resin installations which have given long and successful service. Naturally, the durability of ion exchange resins will depend upon the nature of the influent water supply and specific operating conditions.

If you use water, AMBERLITE ion exchange resins may provide an effective and economical solution to your problem. Your water conditioning engineering firm is qualified by experience to show you how AMBERLITE resins can serve you best. Write for our 24-page booklet, "If You Use Water" for full details on how AMBERLITE resins can soften, deionize, dealkalize or deacidify water.

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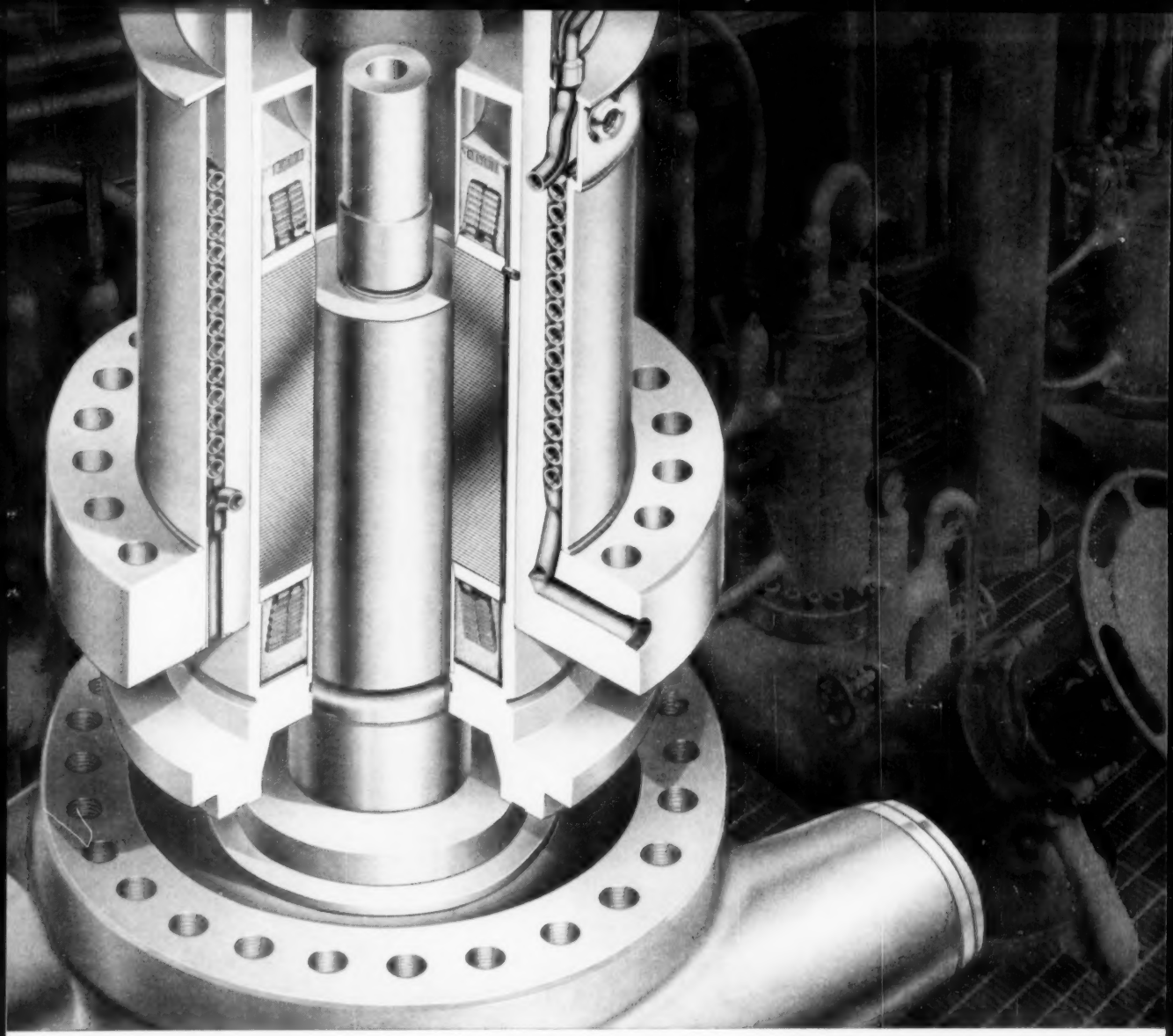

New Removable Stator Design, "Canned" Motor-Pump (exploded cutaway view)

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Controlled circulation boilers equipped with Westinghouse "canned" motor-pumps have a higher unit efficiency, are more reliable and are easier to operate and maintain.

The pump and motor casings completely enclose the pump shafting... Conventional shaft seals and complicated seal injection systems are eliminated.

Watertight Inconel cans encase the rotor and stator . . . All windings are dry and clean for years of trouble-free operation.

New unit construction of stator and rotor permits easy, fast (24-hour), in-your-shop inspection, overhaul and repair... Reliability and availability of pumps are at a maximum.

For more information on how Westinghouse "canned" motor-pumps will improve controlled circulation boiler performance, contact your Westinghouse sales engineer, or write Westinghouse Electric Corporation, Atomic Equipment Department, P. O. Box 217, Cheswick, Pa. J-57011

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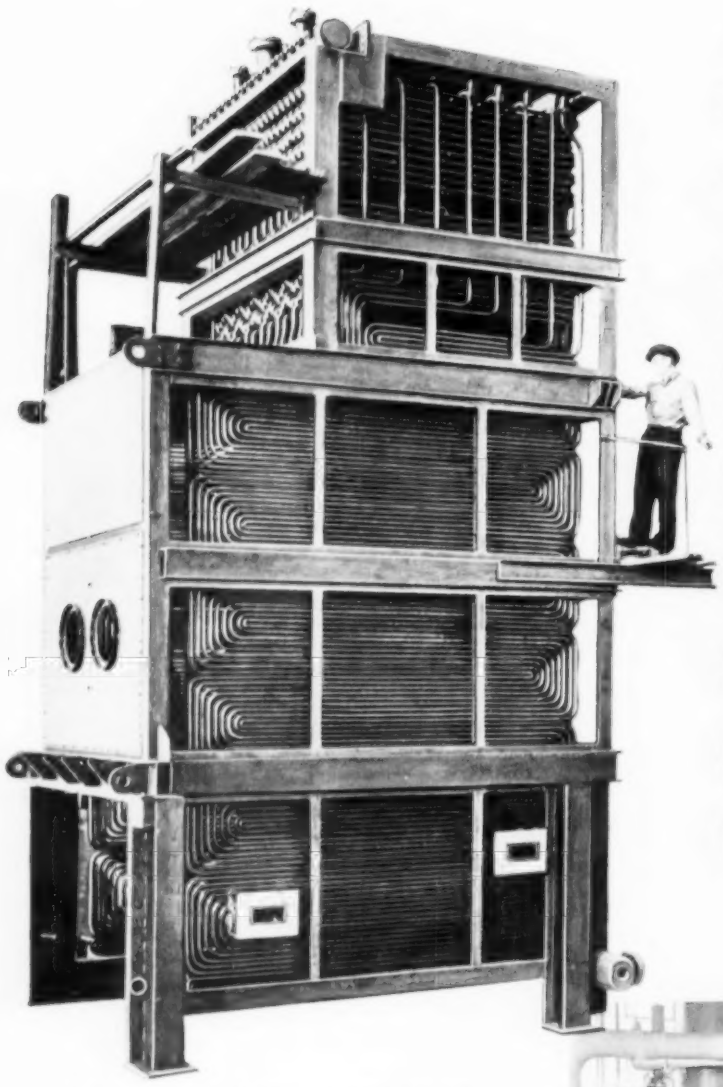
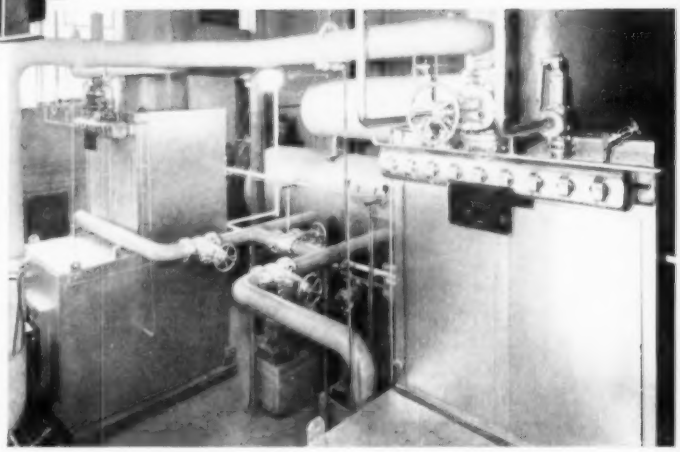


In new plants large and small...

The C-E high temperature water boiler offers savings of 10 to 20%

Shop assembly view showing steel frame and pressure parts for 25 million Btu unit prior to installation of refractory, insulation block, and welded gastight casing.



Compactness of C-E HCC Boilers is demonstrated in this view of two 10 million Btu units installed at a new Michigan high school.

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C-E

C-1910

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT. NUCLEAR REACTORS. PAPER MILL EQUIPMENT. PULVERIZERS. FLASH DRYING SYSTEMS. PRESSURE VESSELS. SOIL PIPE.

The list at right points up the versatility and widespread acceptance of Combustion Engineering's HCC boiler. For industrials, schools, institutional use, military bases—wherever there is extensive space to be heated—C-E high temperature water has a place.

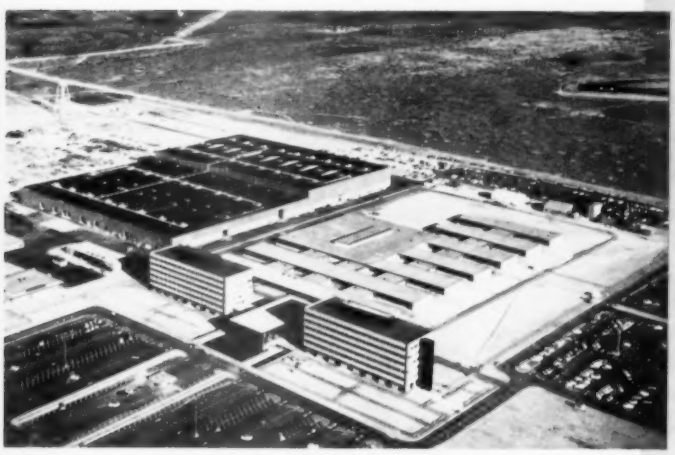
Featuring the same principle applied by Combustion in many of its large utility boilers, the C-E LaMont Controlled Circulation Hot Water Boiler offers a compact and effective arrangement of heating surfaces. This design gives precision temperature control, and, dependent upon local conditions, the HCC can save 10 to 20 per cent in maintenance and operating costs—a significant factor when considering a heat source.

Available in a wide capacity range—from 10 to 300-million Btu's—these boilers operate at water pressures up to 500 psi and temperatures to 470 F or higher. The smaller capacity HCC's are completely shop-assembled, while the intermediate and large units are shipped in varying stages of assembly. This C-E practice greatly reduces erection costs.

If you are in the market for boilers, either for space heating or process requirements, it may prove greatly to your advantage to investigate C-E high temperature water as your heat source.

Because individual needs vary, *both* steam and hot water have their applications. Combustion Engineering can furnish either, and our engineers are exceptionally qualified to discuss *impartially* with you or your consultants the method most suitable for your situation.

Write for further details on Combustion Engineering's High Temperature Water Boilers.



One of the many large plants using C-E High Temperature Water Boilers is Convair-Astronautics Division of the General Dynamics Corporation. Installed at this new $40-million center for Atlas Intercontinental Ballistic Missile research, development, manufacture, and primary testing are two 30-million Btu HCC Boilers.

Representative list of C-E HCC Boilers in service, under construction, or on order

	No. of Units	Normal Output ea.—Btu/Hr. (millions)	How Fired
A. E. Smith High School Riverview, Michigan	2	10	Oil
J. Bishop & Co. Malvern, Pa.	1	12	Oil
Colorado State College Greeley, Colo.	1	60	Oil—Nat. Gas
Cross Company, The Frazer, Michigan	2	12	Nat. Gas—Oil—
Defense Construction Ltd. Camp Gagetown, N. B., Canada	3	70	Pulv.Coal—Gas
Erie Mining Company Aurora, Minn.	2	65	Stokers—Oil or Gas
Convair Astronautics Div. General Dynamics Corp. San Diego, Calif.	2	30	Oil—Nat. Gas
General Motors Overseas Santos, Brazil	1	12	Oil
Hillcrest Medical Center Tulsa, Oklahoma	1	30	Nat. Gas
Marquardt Aircraft Co. Ogden, Utah	2	12	Oil—Nat. Gas
Michigan State University Oakland, Michigan	1	12	Oil—Nat. Gas
New Florida State Prison Raiford, Florida	2	30	Oil—Nat. Gas
North Carolina Wesleyan College Rocky Mount, N. C.	2	18	Oil—Nat. Gas
U. S. Air Force Academy Colorado Springs, Colorado	3 2	100 30	Oil—Nat. Gas
U. S. AIR FORCE:			
Clinton County Air Force Base Wilmington, Ohio	1	16	Stoker
Dover Air Force Base Dover, Delaware	3	50	Oil—(Fut. Coal)
Forbes Air Force Base Topeka, Kansas	3	42	Oil—Nat. Gas (Fut. Coal)
Grand Forks Air Force Base Grand Forks, North Dakota	2	25	Stokers—Oil
McGuire Air Force Base Wrightstown, N. J.	4	50	Stokers
Minot Air Force Base Minot, North Dakota	2	25	Stokers—Oil
Plattsburgh Air Force Base Plattsburgh, N. Y.	2	50	Oil
Portsmouth Air Force Base Portsmouth, N. H.	2	110	Oil—Nat. Gas (Fut. Coal)
Wright-Patterson Air Force Base Dayton, Ohio	1	30	Stoker
Wuthsmith Air Force Base Oscoda, Michigan	2	25	Stokers
Air Force Base Torejon, Spain	3	43	Oil
U. S. Navy Auxiliary Air Station Fallon, Nevada	2	15	Oil

THE BAYER CO. *proudly Announces* its 50th Year *supplying* SOOT BLOWERS *to the* NATION'S BOILERS

Since 1908 the Bayer Company has supplied soot blowers for boilers, superheaters, economizers, oil stills, and other fired equipment throughout the country.

Proven through its many installations, the Bayer single-chain design assures precise sequential operation of valve and element, rotation of the latter not taking place until *after* full steam flow has commenced. This means positive and efficient cleaning over the entire arc . . . without wasted steam.

The Bayer Balanced Valve Soot Blower is simply operated by a pull on the chain which opens the cam-actuated valve. Continued pulling of the chain slowly rotates the element through its cleaning arc, at the end of which the valve automatically closes.

During its 50 years of continuous specialized service the Bayer Company has equipped more than 35,000 boilers with dependable soot blowers. Engineered for long life and efficient performance at high temperatures, the minimal steam consumption and low maintenance of Bayer Soot Blowers assure economical and trouble-free operation.

ADVANTAGES OF THE BAYER BALANCED VALVE SOOT BLOWER

single chain operation
individual elements adjustable for high pressure service by orifice plate valve
full steam pressure over entire cleaning arc
selected gear ratios for optimum rate of element rotation
minimum pressure drop through valve body
machined air seal with spring loaded seat
complete vacuum breaker protection
precision swivel tube alignment lessens stuffing box packing needs
load carried on ring type thrust bearings.

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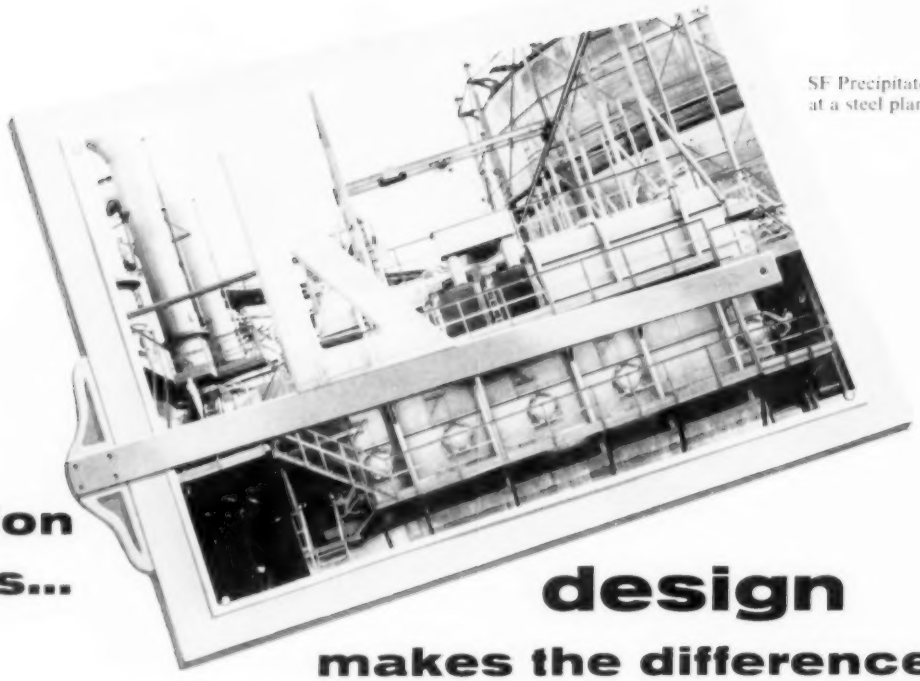

SF Precipitator at a steel plant.

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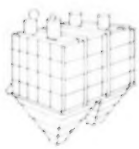
Lower installation cost of Buell's time-proved simplified design makes erection faster and easier. Spiralectrodes, for example, are self-tensioning, require no weights. Flexibility of power supply means easier installation, operating safety.



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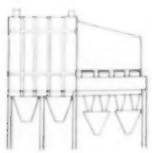

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Editorial

A Forward Step

In 1959 The American Society of Mechanical Engineers will inaugurate a new publications policy for *ASME Transactions*. Now in its eightieth volume, *Transactions* has been published as twelve monthly issues, four of which have been known as the *Journal of Applied Mechanics*. Under the new policy *Transactions* will appear as five quarterlies designated as follows: *Journal of Applied Mechanics, Journal of Basic Engineering, Journal of Engineering for Industry, Journal of Engineering for Power, Journal of Heat Transfer.*

Mechanical engineering is an extremely broad field. While it may have been true in the early days of ASME history that large numbers of its membership were interested in the complete subject matter of mechanical engineering, such is no longer the case. The new publications policy recognized this by providing quarterly publications in some of the principal mechanical engineering specialties. The policy is flexible enough to permit the additions of more quarterlies as evidenced by member interest and availability of quality papers in sufficient quantity.

At times there have been criticisms that the so-called founder societies have been unable to adopt realistic policies to keep up with the increasing flood of technical information. The new *Transactions* policy is evidence that ASME, through the leadership of its Publications Committee and editorial staff, is doing something to serve the membership by fulfilling one of the primary objectives of the Society, namely, promoting the art and science of mechanical engineering through the publishing of papers and reports of value to engineers.

The Geneva Conference as an Institution

The release of the atom's energies produced among its interested followers as much of a chain reaction in the way of meetings and reports as that occuring between atoms in a successful fission. Some several years ago many of the sponsoring agencies recognized others of similar or complimentary interests and combined their major reporting sessions into fewer and more original conclaves of appeal to their several partisanships. Two outstanding creations of this pooling are the Nuclear Congress and the Atomic Industrial Forum. The United Nations International Conference on the Peaceful Uses of Atomic Energy was, on the other hand, aimed to bring together all groups and all nations whatever their interests.

The First International Conference, held August, 1955 in Geneva, was hailed as a highly successful international science conclave. It brought together nations actively engaged in the study and the harnessing of the atom with those countries not so engaged for one reason or another but yet hungry for information. More important, the science representatives of nations of diverse political philosophies openly exchanged ideas and revealed what had been up to that time individually secret material. Certainly a second such conference was in order.

The Second International Conference again held at Geneva in September of 1958 was impressive according to early reports for its size, its scope of subjects, its exhibits. We are most grateful to the 5th Annual Atomic Industrial Forum, staged November 10-12, in Washington, D. C., however, for a pungent but realistic look at the Geneva Confernece and its future. The question of whether the Conference will become an Institution was met head on. C. D. Goodman, Schlumberger Well Surveying Corp., and Corbin Allardice, International Bank for Reconstruction & Development, were the ones who observed with a critical eye and favored the Forum with their remarks. These remarks ranged from "a 4-ring circus" to "suffered from a plethora of social events." Both felt the Conference in its present form was of questionable value. The preference seemed rather for a series of meetings, international in complexion to be sure, but confined to a specific area of interest.

Our own experience with such activities indicates that meetings on such broad subjects as the Peaceful Uses of Atomic Energy must necessarily fall of their own weight. The larger the range of interests, the sooner the fall. We, as a publication, would endorse the furtherance of smaller meetings confined to individual specific areas of interest.

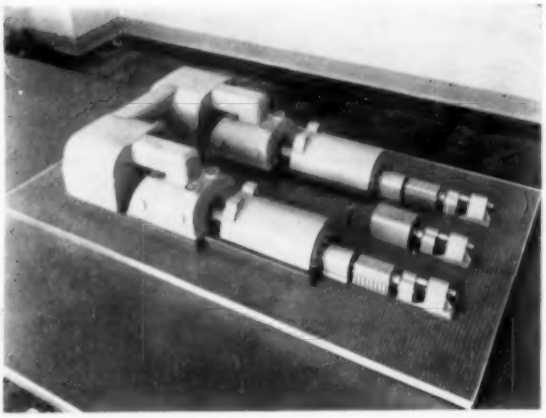


Fig. 1—Model of Bergen Turbine-generators Nos. 1 and 2, showing shaft-driven boiler feed pumps and motor-driven spare

By R. A. BAKER†

Public Service Electric and Gas Company

Evolution of the Boiler Feed-Pump Drive*

More than a hundred years ago, the horizontal-duplex feed pump was introduced as a drive separated from the main engine so that water could be fed to the boilers when a ship was docked, and the main engine was not needed. Up to that time designers worked toward using the engine to drive its own auxiliaries where feasible. Today we are witnessing a revival of this concept in large land installations for steam turbine-generators. In the electric-generating stations of the Public Service Electric and Gas Company, this practice has been adopted in the design of four large units now under construction. When the electrical engineers, for good reason, took the exciter away from the outboard end of the main generator shafts of these units, there were persuasive reasons to consider the use of this source of reliable power to drive the biggest power consumer of all the auxiliaries—the boiler feed pump.

IN THE Public Service Electric and Gas Company system, there is ample history to show that during the years all accepted methods of boiler feed-pump drive have worked more or less satisfactorily. Prior to 1930 most of the boiler feed (BF) pumps were steam driven, but in the late 1920's, a number of motor drives were used with steam-driven spares. Both the motor-driven pumps and the steam-driven pumps have performed very well.

In 1938 a 50,000-kw, 1250-psig, 950 F topping turbine unit was installed with extraction turbines to drive the BF pumps. Advantages were (1) variable speed, (2) the exhaust of the topping turbine was available at a constant pressure of 220 psig to supply the BF pump turbines, and (3) this provided extraction steam from the BF pump turbines for feedwater heating that was not available from the topped turbines. Disadvantages were early governing problems, and maintenance of the auxiliary steam supply and exhaust systems.

In 1939 units of 120,000-kw capability were installed. Each with two motor-driven pumps in series; one variable-speed pump driven through an hydraulic coupling, and the other running at constant speed. Primary pump speed is varied to maintain a constant differential across the feedwater regulating valve. Although this improved operation, it still left auxiliary steam supply and exhaust systems, because in these plants it was necessary to install pressure-reducing stations to supply steam for the spare BF pump, condenser air ejectors, and for soot blowing.

By 1946 the development of (1) variable-speed equipment suitable for BF pump drive, (2) mechanical condenser air removal pumps, and (3) air soot blowing were all combined to permit the long-sought elimination of the low-pressure auxiliary steam systems in high-pressure plants. The BF pumps were driven by 3600-rpm motors through hydraulic couplings.

The next step in the evolution of the BF pump drive was the development of the high-speed pump. The developmental installation was made at Kearny Generating Station in 1954–1955, and the first regular installation was made at Linden Generating Station, which commenced operation in 1957. In this, an 1800-rpm

* Contributed by the Power Division of the ASME for presentation at the ASME-AIEE Power Conference, Boston, Mass., September 28-October 1, 1958 as Paper No. 58-PWR-18.

† Assistant Chief Engineer, Electric Engineering Dept.

constant-speed motor is connected to an hydraulic coupling, which drives a step-up gear, which turns the BF pump at speeds around 8300-rpm.

Bergen BF Pump Drives

The Bergen BF pump-drive study was first approached in a manner quite similar to previous Public Service installations of two large turbine-generator units; that is, with a provision for three half-size pumps per unit driven by motors or turbines. When the turbine-generator set was selected as a 290,000-kw, cross-compound 3600-3600-rpm unit with a 50-50 load-split based on the use of identical generators and low-pressure elements, it was apparent that two half-size pumps might well be driven from extensions of the two generator shafts, continuing the symmetrical arrangement, while the third, or spare half-size pump, would be motor driven. Thus, for two turbine-generator units, four 4500-hp motors were eliminated. The estimated cost of these motors, installed complete with controls and switchgear, was about $500,000. Since the shaft-end pumps are located in the space normally reserved for generator rotor withdrawal, a net reduction in building volume is realized, and building cost is lowered. The layout is such that the rotors of the generators can be withdrawn without disturbing the pumps. A further saving results from elimination of speed control for the spare pump, since this unit is expected to run only a very short time during its life. These are the major savings in a comparison with the BF pump-drive practice that was used at Linden Generating Station, the project which preceded Bergen.

The decision to use the main generator shafts for driving BF pumps introduced the necessity of assuring the greatest continuity of generator operation, regardless of interruptions to BF pump operation. The initial concept contemplated the use of a declutching device and a safety shear section in the shaft between the generator and the hydraulic coupling. When it was found that the hydraulic coupling could be arranged to stop its output shaft completely while its input shaft turns at full speed, the use of any means for shearing the shaft was deemed to be unnecessary.

While the possibility of disconnecting the driven apparatus at full speed might be desirable, it was believed that a mechanical coupling which could be disconnected during a very short stop would be satisfactory, since the pump and gear could be stopped by means of the hydraulic coupling.

It was decided that a continuously lubricated gear-type flexible coupling should be used to tie each pump drive to its generator shaft and that a flexible shaft mounted inside a quill shaft, should be used to provide for misalignment between generator and pump. This coupling can be disconnected completely in a relatively short time. It is in a common housing with the sine-wave generator, the tachometer, and their driving gears. This same housing also covers the d-c brush equipment in a separate compartment. Monorail, lifting gear, and so forth, are provided above the mechanical coupling to promote quick assembly and disassembly.

Public Service generators, on the outboard end of their shafts, normally have tachometer equipment and balancing gear. To make it possible to drive the pumps directly by the main shaft, gearing was introduced to establish a small parallel shaft for driving the tachometer and balancing gear. The use of a quill shaft in connection with this installation is expected to be of aid in balancing the collector rings.

If, for any reason, it is necessary or desirable to divorce the pump drive from the main turbine shaft, the hydraulic coupling scoop-tube is positioned to remove all of the oil from the operating circuit of the hydraulic coupling. When the scoop-tube is in the "in" position, a three-way valve is automatically operated to bypass most of the coupling's oil direct to its tank without going into the coupling for removal by the scoop. The hydraulic coupling is equipped with a magnetic brake, which when energized, prevents rotation of the driven shaft. Following any draining of the operating oil by the scoop-tube, a relay permits operation of the magnetic brake after a suitable time delay. Permanent bolts can then be set to lock the driven shaft—and consequently, the gear and pump—from any rotation whatever.

If it is desired to disconnect the gear-type, mechanical coupling entirely, it can be done at any chosen time by shutting down the main turbine for the short period

TABLE 1—LIST OF RECENT GENERATOR SHAFT-DRIVEN BOILER FEED PUMP INSTALLATIONS

Station Name and Unit No.	Owner	No. of Pumps	Capacity, 1000 lb/hr	Pressure — Suct., psig	Pressure — Disch., psig	Water Temp., F	Speed, rpm	Driver (See Code)	Pump Manufacture
Arthur Kill 2	Consolidated	1	2,800	183	2,623	363	3,510	S-H	Byron Jackson
	Edison Co.	1	1,400	183	2,723	363	3,580	M (Spare)	Byron Jackson
Astoria 3 and 4	Consolidated	2	2,800	183	2,623	363	3,510	S-H	Byron Jackson
	Edison Co.	3*	1,400	183	2,723	363	3,580	M (Spare)	Byron Jackson
Bergen 1 and 2	Public Service	4	1,050	459	2,886	425	8,720	S-H-G	Worthington
	Elec. & Gas Co.	2	1,050	459	2,886	425	8,897	M-G (Spare)	Worthington
Dickerson 1 and 2	Potomac Elec.	2	1,400	179	2,844	330	3,525	S-MD	Worthington
	Power Co.	2	1,400	179	2,844	330	7,000	T (Spare)	Worthington
Little Gypsy 1	Louisiana Power	1	1,800	175	2,415	350	3,500	S-H	Worthington
	& Light Co.	1	1,090	320	2,180	315	3,585	M (Spare)	Worthington
Mercer 1 and 2	Public Service	4	1,130	472	2,958	400	8,840	S-H-G	Worthington
	Elec. & Gas Co.	2	565	472	2,958	400	8,725	M-G (Spare)	Worthington
Pittsburgh 5 and 6	Pacific Gas & Electric Co.	4	1,200	200	2,900	350	3,500	S-H	Worthington

Code: S = Main Generator Shaft Drive; H = Hydraulic Coupling; MD = Magnetic Drive; G = Gear; M = Electric Motor Drive; T = Steam Turbine Drive

* 2 Spares for No. 3 Unit.
1 Spare for No. 4 Unit.

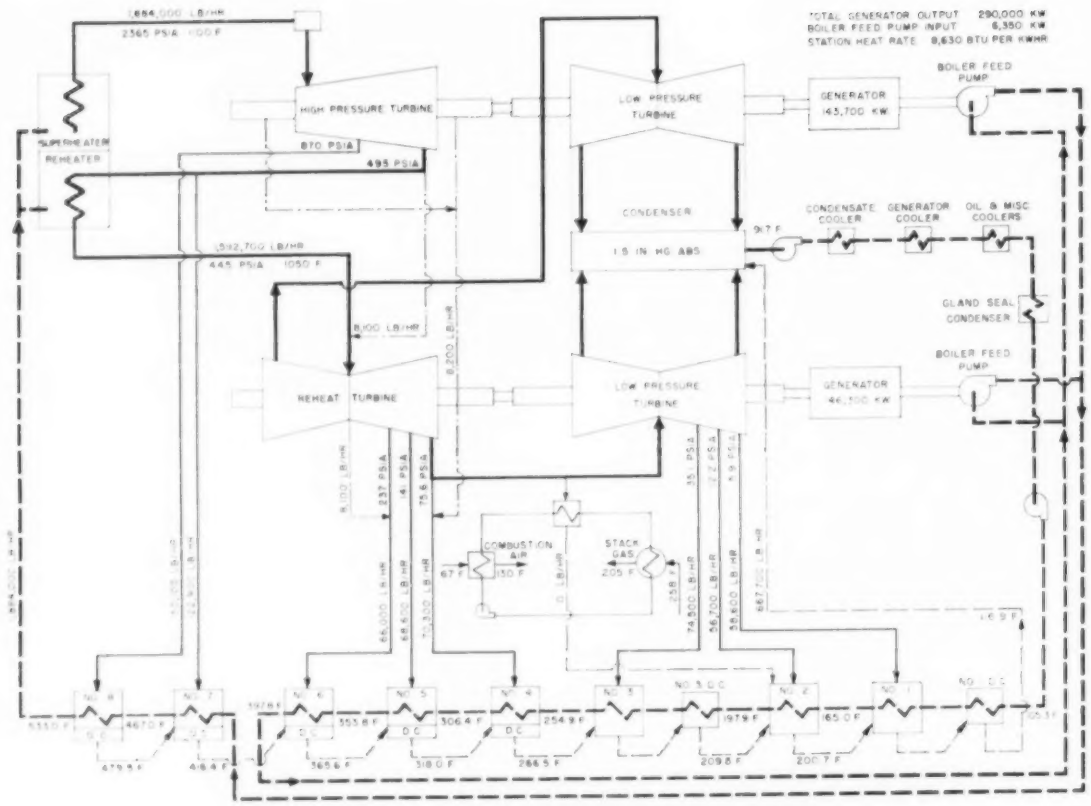


Fig. 2—Feedwater heating cycle, Nos. 1 and 2 units of Bergen Generating Station

required. By means of the equipment mounted in the coupling enclosure, the coupling cover is unbolted, the coupling sleeve is pushed to one end, and a separate sealing plate is attached to the end of the coupling housing to seal in the driving shaft completely and to allow the turbine-generator to be returned to independent service. The BF pump drive can, of course, be restored by reversing the process. The two shaft-mounted halves of each gear-type coupling are spaced about 4-in. apart to allow room not only for the expected expansion of the generator shaft from its point of anchorage, but also to provide the clear space desired for sealing up the coupling.

The bearings of the hydraulic coupling are lubricated by oil delivered from the main turbine's oiling system to insure lubrication whenever the turbine is running. This oil is returned to the turbine by an overflow line from the hydraulic coupling's oil reservoir.

In a drive arrangement such as this the spare pump must be capable of starting automatically on failure of either of the shaft-end pumps and it must be able to sustain full boiler pressure for hot restarts following short-time interruptions in main unit operation. Flow control will be accomplished by regulation of the variable speed shaft-end pump which remains in service.

Mercer BF Pump Drives

Design of our Mercer Station, commenced in 1957, is following closely the Bergen design. Initially this station will have two 320,000-kw cross-compound, 3600-3600-rpm units. BF pumps will again be generator shaft-end driven with only a few differences from the Bergen arrangement. The spare or hot restart, pumps will be quarter-size, rather than the half-size duplicates of the generator shaft-end pumps at Bergen. There will be one such spare for each turbine-generator unit, and provision will be made to cross-connect the two spares in order to provide full pumping capacity to either main unit, should either of its shaft-driven pumps be incapacitated for a prolonged period.

The Mercer BF pumps themselves will vary somewhat from those at Bergen on account of the fact that the main turbines will rotate in opposite directions. Of the 33 items making up the assembly of a pump's rotating element, nine items will not be interchangeable with their Bergen and Linden counterparts because of this difference. Since the head to be developed by the Mercer pumps will be higher than that at Bergen, the step-up gear units will have different ratios to give the necessary higher rotational speed.

At Linden and Bergen, single increase gear units are being used to produce the high speeds required by the pump shafts, and this single step elevates the pump shaft above the shaft of the driver about 16½-in. At Mercer, epicycloidal step-up gear units will be installed, and there will be no offset in the shaft counter lines.

At Bergen—as well as at Linden—the BF pumps are located within the turbine room, while at Mercer the

entire generator and BF pump-drive assembly will be outside of the turbine room on the outdoor deck of the structure. Each of the BF pumps will have its own individual removable housing. A small lifting device designed for use inside the housing will be available, and this should reduce the frequency of housing removal.

Another feature of the Bergen and Mercer BF pump drives is worthy of mention. While the connection between the generator and hydraulic coupling shafts at Mercer and Bergen will be the product of two different turbine builders, they will be similar basically in that both take advantage of the ability to shut off the transmission of power to the hydraulic coupling completely by emptying the oil from its operating circuit. While Bergen will obtain a complete mechanical separation of generator shaft and hydraulic coupling by sliding away the sleeve of a toothed coupling, the other will remove a spacer coupling. In each case, it is estimated that a few hours will be required for such disconnection and return of the turbine to service.

Use of two quarter-size spare pumps, instead of half-size, saves more than the $100,000 differential represented by the size of the pumping units. Reduction of the largest motor size from 4500- to 3000-hp was one of the important factors supporting the decision to use a 26-kv, instead of a 220-kv, emergency start-up transmission line. The resulting saving was substantial.

Design Considerations

The use of half-size pumps driven from the two generator shafts of a cross-compound turbine-generator unit offered the following advantages in the design of the Bergen and Mercer plants:

1. A dependable supply of torque to the BF pumps.
2. The design of all the components in the pumps and drives has been proven in service.
3. While it lacks interchangeability with the main pumps, the quarter-size spare pump is of ample size for starting and stopping the main unit, and its smaller motor eases the design requirements of the auxiliary power supply.
4. In starting up a cold main unit, the electric-driven spare pump can be run at any time.

At Bergen and Mercer, Public Service practice has been continued from other stations in respect to auxiliary power. The electric-driven auxiliaries can be supplied from the generator bus or the auxiliary bus; with automatic switch-over to the other bus provided.

Any comparison of the economics of the shaft-drive with the alternative means available involves consideration of numerous intangibles.

A comparison with motor-driven BF pumps reveals not only the saving in first cost of motors, switching, and transformer capacity, but also an increase in the net output of the turbine-generators by the amount of the motor and electrical transformation losses, about 0.1 per cent for the 2400-psi unit.

For a given steam flow, there is inherent in the shaft-drive arrangement a reduction in power available for electric generation. As a result of this, a unit cost saving may be realized, theoretically at least, either by increasing the capability of the steam-end of the unit enough to maintain the electric output that could be obtained without the shaft-end BF pump drive, or by installing a slightly smaller generator. By either method, a reduction in capital cost per net kw of station output can be obtained. Actually, our customary practice was followed in specifying the balance between the capabilities of the turbines and generators for Bergen. This seemingly anomalous decision resulted from the new policy of turbine manufacturers to design the turbine to carry nominal generator rating with 3½-in. Hg exhaust pressure, which is greater than the figure normally specified. With this additional increment of margin, it was considered unnecessary to specify a greater than usual turbine capability. At Mercer, the generator capability is slightly higher than customary.

Split pumping systems will be used both at Bergen and Mercer Generating Stations. The condensate pump takes the condensed steam coolers, oil coolers, etc., and then delivers it to the suction of a secondary pump which raises the pressure high enough (about 500 psig) to pass through six feedwater heaters and enter the suction of the BF pump with adequate net positive suction head to prevent flashing. From the BF pump, the water flows through two closed heaters before entering the boiler. An economic study showed this to be the most favorable of several combinations.

Reliability and Ease of Maintenance. Judicious selection of BF pump drives cannot rely strictly on economics. Reliability, accessibility, and ease of maintenance must also be seriously considered.

Fig. 3—Elevation of boiler feed pumps, drive and generator typical of Nos. 1 and 2 units of Bergen Generating Station

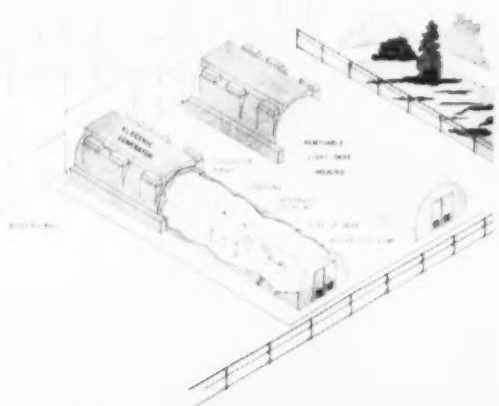
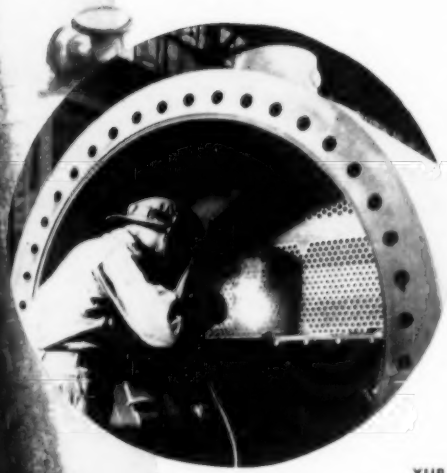


Fig. 4—Perspective view of outdoor installation of boiler feed pump, drive and generator typical of Nos. 1 and 2 units of Mercer Generating Station

HEADING FOR 5000 PSI

YUBA ALL-WELDED FEEDWATER HEATERS

Tubes are welded into tube sheets and then extensively tested against specimens of rolled joints. At elevated pressures, rolled joints leaked and blew out of the test bombs, but at 9600 psi the welded tubes held firm.



Twenty-five years ago it was an accomplishment to put 1000 psi into a feedwater heater. Ten years ago, 2500. Today Yuba feedwater heaters are at 4000 psi. Next step — 5000.

A chief reason for the present high pressures and the promise of even higher is Yuba's all-welded Multilok Closure design: tubes welded, not rolled, into tube sheets; shells welded to heads and channels. No flanges or bolting required. In the Multilok Closure, a split key ring in shear absorbs the force resulting from the internal pressure on the cover, and the steel torus ring welded to the channel and to the cover provides the hydraulic seal. Destructive tests on Yuba's well-known Multilok Closure proved the strength of the design of the split key ring construction and the soundness of the torus ring design.

The all-weld design already has set an industry standard and its proved performance has brought orders from the major power companies here and abroad.

Your inquiry is cordially invited.

Power equipment engineered and manufactured by
YUBA HEAT TRANSFER DIVISION
Honesdale, Pa.

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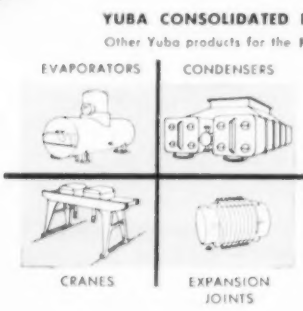
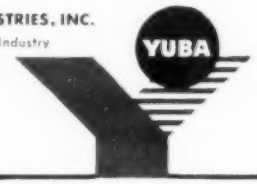
Production facilities in the west
YUBA MANUFACTURING DIVISION
Benicia, Calif.

YUBA CONSOLIDATED INDUSTRIES, INC.
Other Yuba products for the Power Industry





PLANTS AND SALES OFFICES

SHOT CLEANING*—

R. E. CHAPPELL

Manager, Products Design,
Diamond Power Specialty Corporation

R. D. MEYER

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Philadelphia Electric Company

This paper pertains to the development and application of shot cleaning in this country for cleaning boiler surfaces that are below the ash-softening temperature. It includes an account of the successful operation of a system on a tubular air heater at the Philadelphia Electric Company. Shot cleaning has proved to be a highly effective cleaning device and eventually is expected to be standard equipment on many boilers.

SINCE the introduction of tubular-type boilers the ability to clean a boiler has been a troublesome problem in maintaining efficient operating conditions. In 1950, the author's company intensified its program on boiler tubes to determine the best methods for controlling deposit build-up and reducing boiler-cleaning cost. In this paper, only one phase of this program is being considered, namely, the work pertaining to the development of shot cleaning as a means of effecting economical deposit control.

The basic principle employed in shot cleaning is very old. It stems from sand blasting, which uses a stream of very coarse abrasive material directed against the areas to be cleaned. The kinetic energy in the abrasive particles is expended by the scouring action against the fouled area. For example, in a spreader-stoker-fired boiler, the fly ash that is present in the flue gas often has sufficient mass and velocity to clean the boiler tubes in the same manner as would a sand-blasting operation. Other methods employing this same principle have been the use of shot guns by boiler operators to remove stubborn deposits and the use of wood or asphalt pellets projected at a high velocity into the boiler by hand-operated air guns or by special soot blowers (1).[1]

Evolution of Shot Cleaning. In 1949, the Ekstrom Company of Sweden, began building shot-cleaning devices using $^3/_{16}$-in. iron shot falling by gravity over a heat exchanger. The shot was distributed evenly over the heat exchanger and in falling, ricocheted from tube surface to tube surface. The velocity of the falling shot was sufficient to do a satisfactory cleaning job, but was not great enough to damage the tube surface.

In 1951, Diamond started a program of projecting $^1/_2$-in. pellets to clean very tenacious slag deposits in areas not readily accessible to soot blowers. At about the same time, The Babcock & Wilcox Company started investigating the use of a gravity-type shot system for cleaning the air heater of a power boiler.

Recovery boilers next were selected for testing since they offered such difficult cleaning problems. In the pulp and paper industry, the binder in the wood chips is dissolved by chemicals and the resulting residue is called black liquor. This is burned in a recovery boiler to recover the chemicals as a molten smelt or ash. Process steam is obtained as a by-product. The recovery boiler has an extremely high rate of fouling and the convection surfaces are difficult to keep clean because of the extremely small particles of chemical dust in the boiler flue gases.

The first shot-cleaning system by Diamond was on a vertical tubular air heater at the Thilmany Pulp

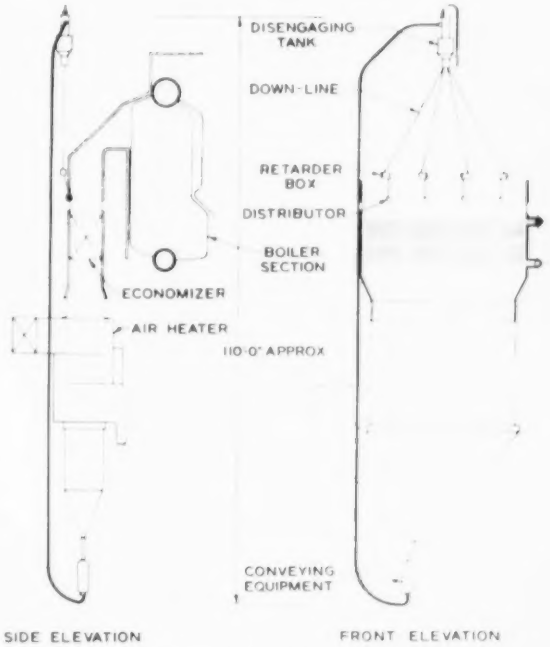

Fig. 1—Typical shot-cleaning system

* Contributed by the Power Division for presentation at the Annual Meeting, New York, N. Y., November 30–December 5, 1958, of The American Society of Mechanical Engineers under the title "Shot Cleaning—Its Development and Use For Cleaning Economizers, Tubular Air Heaters, and Applicable Boiler Sections."

[1] Numbers in parentheses refer to References at end of the article.

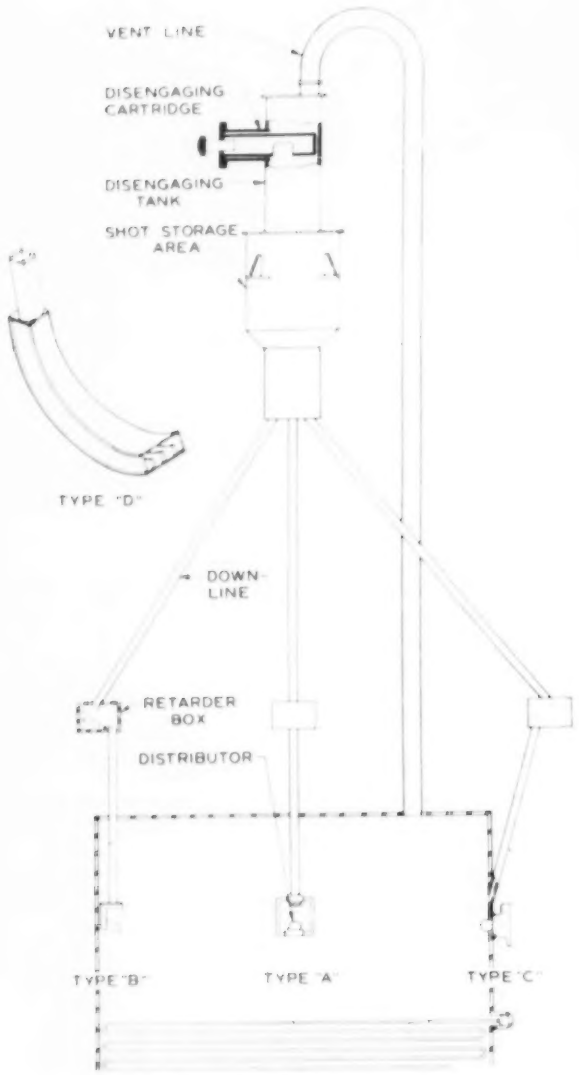

Fig. 2—Shot distributor system

and Paper Company, Kaukauna, Wis. Although some difficulty was experienced with the shot-lifting portion of the system, the cleaning of the air heater was excellent. Subsequently the system was extended to include the economizer section of the boiler, and again excellent cleaning was obtained (2).

A Typical System

Fig. 1 illustrates a typical shot-cleaning system. It consists of a method of pneumatically conveying shot (normally $\frac{1}{4}$ in. diam) from the bottom of the boiler to a point above the area to be cleaned. Shot enters the upper portion of the disengaging tank, shown in detail in Fig. 2, and is separated from the lifting medium which may be air, flue gas, or steam. The lower portion of the disengaging tank is used for shot storage and down-line distribution. The lifting medium is vented from the top of the disengaging tank and piped into the boiler setting at any convenient point. The down-lines are located symmetrically in the bottom of the disengaging tank to ensure an equal gravity flow of shot to each retarder box.

The inlet to the retarder box is at an angle to direct the shot away from the opening of the line connecting the retarder box to distributor. The incoming shot hits a bed of shot and loses its falling velocity before it enters the line to the distributor. The retarder box allows the shot to fall onto the distributor at a predetermined velocity to be uniformly distributed over the surface to be cleaned. The retarder boxes are located outside the boiler casing for accessibility.

The shot cascades onto and down through the heating surfaces, removing small particles of ash deposits. After falling through the heating surface, the shot is collected at the bottom of the hopper and is ready to be recycled. Most of the ash removed by the shot is carried away by the gas stream. The heavier ash particles fall into the hopper and are recirculated along with the shot until they are broken up into fine particles and carried away by the gas stream.

The system is so designed that no shot bounces over or is carried by the gas stream into other sections of the boiler where it cannot be recovered.

The system is completely automatic and operates on a relatively short time cycle so that no appreciable amount of deposit is permitted to build up on the heating surfaces. This maintains a uniform draft loss across the boiler section and gives high heat-transfer efficiency.

The shot-cleaning system, as illustrated in Fig. 1, consists of three major areas of development:

Shot distribution.
Hoppers and shot separation.
Shot conveyance.
1. Light-phase.
2. Pressure-lift.
3. Hyperflow.

Shot Distribution

Fig. 2 illustrates the necessary shot-distribution equipment located above the area to be cleaned.

The early shot-cleaning installations used a distributor which was located centrally over the heating surface and distributed shot in a 360-deg pattern. This distributor, now known as a Diamond type A, is made of a hemispherical or dome-shaped replaceable casting. It is limited to an 800 F gas-temperature zone to maintain the hardness of the casting to give good bounce characteristics to the shot.

It is not always possible to install a type A distributor through the roof because of outside interferences. Also, it should not be used on a boiler with a sloping roof where the retarder box would be located internally. Because of these considerations, the type B distributor was developed. It is similar to the type A, except that it is located next to the face of the wall and distributes the shot in a 180-deg pattern. This distributor is also limited to an 800 F gas-temperature zone.

The height of the distributor above the area to be cleaned and the height of the retarder box above the distributor have to be held within certain limits to give a good shot-distribution pattern. On some boilers, the roof height above the area to be cleaned is too great to permit installing the type A or B distributor. The

type C distributor was developed which is mounted into the boiler casing with its down-line located on the outside. It distributes shot in a 180-deg pattern and has a gas-temperature limit of 1350 F. The type C distributor plug can be rotated to present a new surface to the falling shot and is externally replaceable.

The type D distributor is a ski or chute type developed to project the shot to areas beyond the normal range of the type B and C distributors. In most cases, the type B or C distributor is used in conjunction with the type D distributor to insure complete surface coverage.

Many tests were made to develop distributors to give satisfactory cleaning patterns. The type A distributor adequately cleans an 8-ft × 8-ft area. The area cleaned by the type B and C distributors is approximately 8 ft wide × 6 ft deep.

Concurrent with the development of the distributors, many types of shot were tested to determine their distribution patterns. One-quarter inch chilled cast-iron shot of 650 Brinell hardness was initially used and had a good distribution pattern, but was found to have the disadvantage of being easily fractured. The fractured pieces of shot aggravated the problem of high wear rate on the conveying equipment. Since the introduction of $\frac{1}{4}$-in cylindrical steel punchings and $\frac{1}{4}$-in. malleable-iron shot, the wear problem has been alleviated, although their distribution patterns are not as good as the cast-iron shot.

In addition to the development of the distributors and the type of shot, it was necessary to determine the quantity of shot required for various types of ash deposits. The quantity of shot lifted depends upon the size of the area to be cleaned and the type of fuel being fired. For oil or pulverized-coal-fired boilers, the shot rate to clean tubular air heaters and economizers may be below 20 lb per hr per sq ft of cross-sectional area. Recovery boiler tubular air heaters may require less than 50 lb per hr per sq ft of cross-sectional area and the economizers may require more than 100 lb per hr per sq ft of cross-sectional area.

Hoppers and Shot Recovery

After the shot completes its vertical drop through the heating surface, it falls into a hopper and is collected for recycling. The size and shape of this hopper are quite important in providing proper collection of the shot to prevent carryover into the dust-collecting equipment.

On the initial installations, shot build-up was experienced where the hopper slopes were not at a steep angle. This had to be corrected by redesigning the hopper in the field. Care had to be taken that the angle of the hopper slopes would not allow the shot to bounce over into other boiler sections. The design of the hopper was made to maintain a gas velocity sufficient to entrain most of the ash particles and carry them out of the hopper.

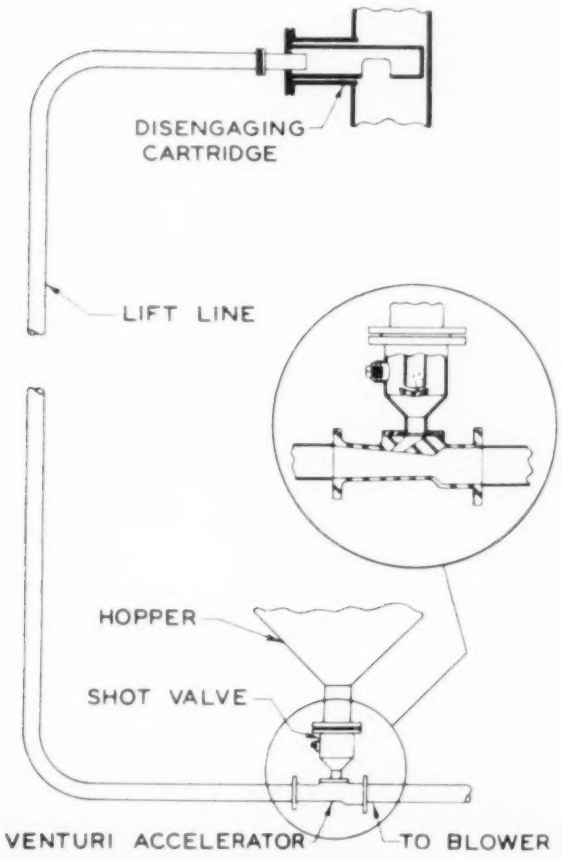

Fig. 3—Light-phase lift system

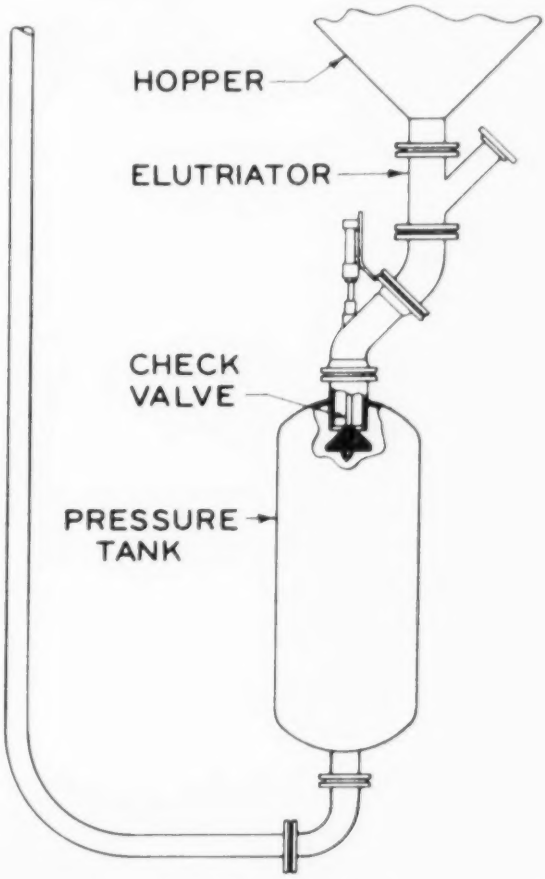

Fig. 4—Pressure-lift system

To reduce further the amount of ash collected with the shot, a relatively high-velocity air stream may be introduced at the hopper bottom. The shot and ash mixture falling into the hopper is washed with this air to carry small particles of ash up into the gas stream where they are swept out of the hopper. This washing process is known as elutriation. Air or gas may be used to give a washing velocity of approximately 2000 fpm in the throat of the elutriator.

There are three major types of pneumatic shot-lifting systems, namely, light-phase, pressure-lift, and Hyperflow (3). The initial shotcleaning development was on the light-phase system employing a high-velocity, low-pressure air or gas stream into which shot is injected and conveyed to the disengaging tank at the top. Later developments were on the pressure-lift and the Hyperflow systems which employ high-pressure, low velocity air to force the shot up the lift line by pressure.

Shot Conveyance

Light-Phase. The general arrangement of the component parts located below the hopper is shown in Fig. 3. Starting at the hopper outlet, the shot particles are fed into the venturi accelerator through a shot valve used to control the rate of shot. The venturi accelerator admits the shot into the gas stream and gives it rapid initial acceleration.

The shot is pneumatically conveyed to the disengaging tank by a controlled gas stream from a heavy duty blower. The blower is sized to give a fluid velocity high enough to insure complete entrainment of the shot. The present installations have the blowers connected to give a positive pressure in the lift line, however, they may be connected for a suction pressure-lift system which has the advantage of more efficient operation of the venturi accelerator, owing to a constant negative pressure at the throat rather than a positive back pressure tending to impede the flow of shot. It has the possible disadvantage of pulling in abrasive materials.

On some of the early installations, a drag-type conveyor was used to control the shot rate and to transport the shot to a vertical lift line, in order to eliminate bends in the lift line. On other jobs where head room was available, a table feeder was installed beneath the hopper and fed shot into a downward sloping pipe connected to the vertical lift line. Where possible, all bends in the lift line are eliminated and only vertical lift lines used. Usually bends are necessary and the life of the lift line is reduced by the wear occurring at the points where the shot changes direction.

The disengaging cartridge, shown in Fig. 2, is designed so that the shot will impinge upon a bed of shot as it is separated from the lifting gas. The shot drops to the bottom of the disengaging tank and the lifting gas is vented to the boiler. Originally, the shot entering the disengaging tank hit a baffle plate or an extremely hard wear casting to deflect it to the bottom of the tank. The wear rate was very high and the life of the baffle plate or the wear casting was approximately 2 weeks. This led to the development of the present disengaging cartridge which has greatly reduced the wear rate.

Pressure-Lift. On the first black-liquor recovery boiler equipped with a light-phase system the quantity of shot lifted was not sufficient to clean the boiler and high wear rate was experienced on the component parts. This led to the development of the pressure-lift.

The shot leaving the hopper, shown in Fig. 4, falls through a check valve into a pressure tank. At the start of the lifting cycle, the check valve is closed and a high-pressure lifting medium (air, gas, steam, etc.) is admitted into the tank. The shot is forced into a constant-diameter lift line at the bottom of the tank with a certain compactness where the void space is filled by the high-pressure lifting medium. As the shot moves up the lift line the pressure decreases, thereby expanding the lifting medium. When the shot approaches the top of the lift line, the volume of the lifting medium may be many times greater than its intial volume, causing separation of the shot. Slugs of shot are formed which move in the final portion of the lift line at a relatively high velocity. The disengaging section for this system is similar to Fig. 3.

The lifting pressure required for this system is between 1.25 to 1.5 psi per ft of lift line depending upon the length of the lift line. If the available air pressure in the pressure tank is not great enough to lift shot, a secondary air connection may be required in the lift line at the point where slugs of shot form. This additional air will entrain the shot and cause it to flow in a similar manner to the light-phase system.

Although the pressure-lift system increased the quantity of shot lifted, as compared with the light-phase system, it did not measurably reduce the wear on the lift line. Special type wear laterals were developed to replace the bends in the lift line. They decreased the wear rate but were found to have a higher pressure drop than a long-radius bend.

Hyperflow. The Hyperflow lift system utilizes the force of a high-pressure fluid (air, gas, steam, etc.) to move the shot up the lift line. Shot leaving the hopper falls through a check valve into a pressure tank as illustrated in Fig. 5. The check valve is closed only during the lifting phase of the shot-cleaning cycle. High-pressure fluid is admitted to the pressure tank to force the shot out of the tank and up the lift line into the disengaging section.

In the Hyperflow system, the shot flows up the lift-line as a compact bed to give a high shot flow rate with a low solids velocity. This is accomplished by the design of the lift line and by controlling the shot-flow rate at the top of the line. A theoretical Hyperflow lift line is one with a varying taper to keep the differential pressure drop constant as the fluid expands with the decrease in pressure in the line. It is not practical to manufacture a special tapered lift line for each shot-cleaning installation, thus a stepped line is used to approximate the taper. The gas velocity in each section of the lift line will vary between 200 and 800 fpm. A special disengaging cap is provided over the discharge end of the lift line to maintain a back pressure and keep a constant compactness of the shot in the lift line.

The lifting pressure required for this type of a conveying system is approximately 4 psi per ft of lift line. The required amount of lifting medium is dependent on the shot rate necessary to clean the heat exchanger.

System at Philadelphia Electric

A light-phase shot-cleaning system has been in service

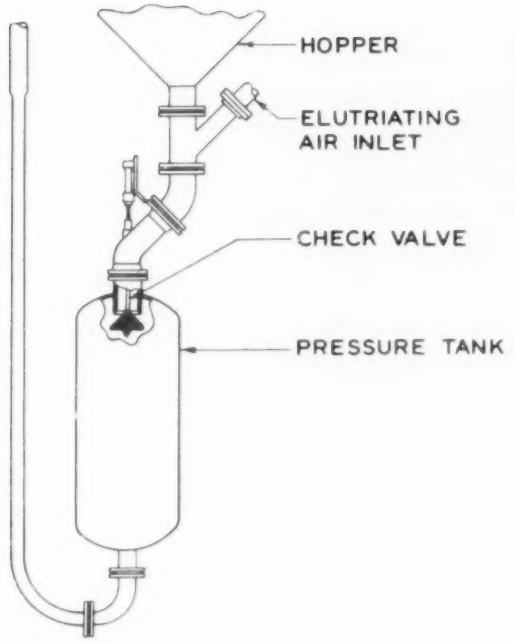

Fig. 5—Hyperflow lift system

at the Delaware Station of the Philadelphia Electric Company since September 1957 to clean tubular air heaters. These air heaters are associated with one of two Babcock & Wilcox boilers which normally operate at 950,000 lb of steam per hr, 1800 psi and 1000 F. The boilers are pulverized-coal-fired, outdoor installations, and operate with a positive furnace pressure of about 25 in. of water. Each boiler serves a 136-megawatt turbine.

There are two tubular air heaters per boiler, each with two vertical gas passes and four horizontal air passes as shown in Fig. 6. Gas temperature is reduced from 600 to 250 F while the air temperature is increased from a preheated inlet temperature of 100 to an exit temperature of 500 F. The final gas pass consists of an upper cold section containing 2016 3-in. tubes and a lower cold section containing 4624 2-in tubes. The horizontal cross section is 17 ft 8 in. by 14 ft 3 in. The original tubes in the upper cold section were aluminum; however, owing to advanced corrosion, they were replaced by steel tubes in September 1957.

Retractable soot blowers equipped with multiple nozzles arranged to blow directly down the tubes in opposition to the gas flow were originally provided at the top of the upper cold section. The soot blower cleaning was not effective and severe plugging of the tubes was experienced. The increase in draft loss across the tubular air heaters resulted in a decrease in fan capacity and a reduction in unit load.

The total draft loss across the cold sections of the air heater is shown in Fig. 7. During the first 4 years of operation, it was necessary to water wash these air heaters six times. Each cleaning involved a three-day outage of the boiler. The total costs due to cleaning and reduction in capacity between cleanings was estimated to be over $60,000 per year for the two boilers.

In September 1957, the original air-heater soot blowers were removed from one boiler and a light-phase shot-cleaning system installed. This system was designed by the Diamond Power Specialty Corporation in cooperation with the Engineering and Operating Departments of the Philadelphia Electric Company.

The arrangement of the air heaters required two disengaging tanks each. Each disengaging tank has two downlines equipped with Type C shot distributors as shown in Fig. 8. There is a total of four lift lines and four disengaging tanks for this boiler. Because of clearance problems, special retarder boxes were used.

A single blower is used to supply air for the four lift lines. Inlet air at 175 F to the blower is taken from a nearby hot-air duct to reduce condensation to the shot-cleaning equipment.

Each lift line has a diaphragm-operated butterfly shut-off valve ahead of its venturi accelerator. A 6-in. pipe header connects blower to the butterfly valves.

A small hopper 24 in. × 24 in. × 17 in. high was installed beneath each of the two air-heater sections. Each hopper supplies shot to the two shot valves and venturi accelerators below it.

Clearance problems made it necessary to use long-radius bends at the top and bottom of the lift line as shown in Fig. 8. This lift line has a height of 88 ft.

Since this is a plus pressure boiler, it was necessary to use manual slide-gate valves to isolate the external shot-cleaning components from the boiler for maintenance purposes.

An automatic programming panel is located near the blower to permit individual or automatic operation

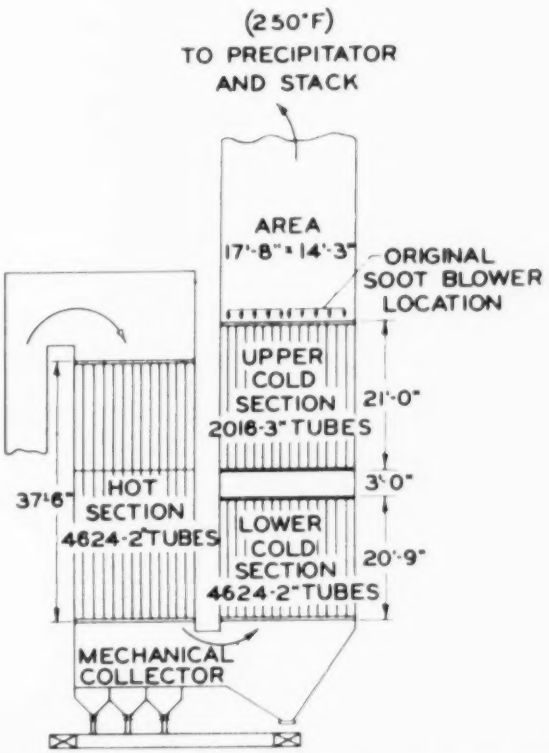

Fig. 6—Philadelphia Electric Company, Delaware Station—air heater cross section (2 air heaters per boiler)

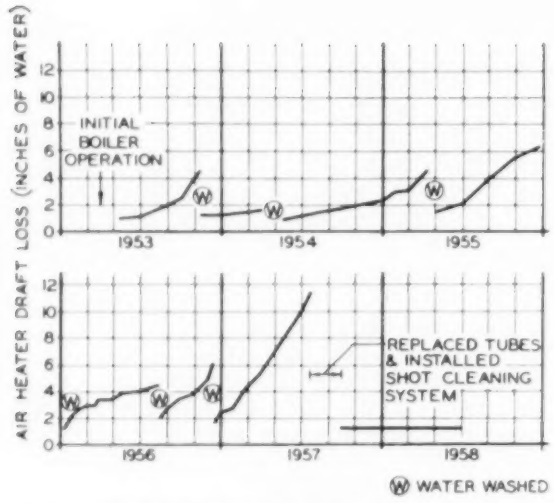

Fig. 7—No. 81 air-heater draft loss at Delaware Station, Philadelphia Electric Company

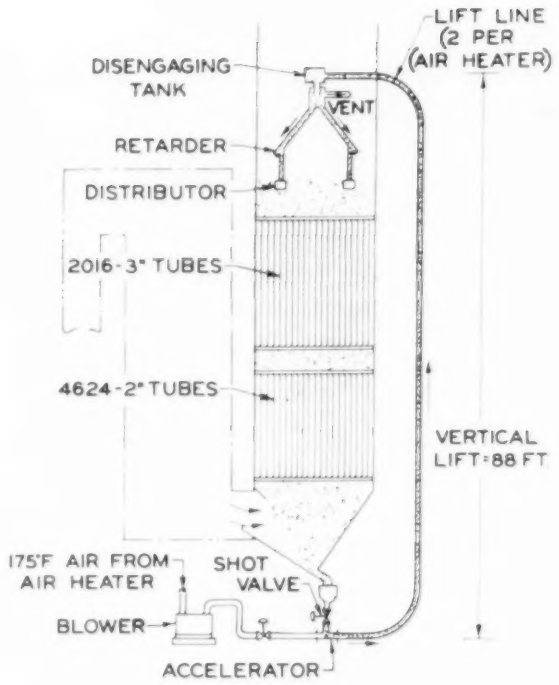

Fig. 8—Air-heater cross section →

of the four shot cleaning lift lines. At present, the shot is circulated through each lift line for a 4-min cycle every 2 hr.

Initially, $\frac{1}{4}$ in. mild-steel cylindrical punchings were used to clean the air heater. This was later changed to $\frac{1}{4}$ in diam malleable-iron shot to give better operation of the shot valves.

During the initial few months of operation, some difficulty was experienced with loss of shot from the system. This was due to inadequate deflecting baffles below the air-heater tubes which permitted some of the shot to bounce into the mechanical dust collectors. A considerable amount of shot accumulated in the fly-ash ducts below the collectors. This condition was corrected by an improvement in baffle design and at present, the quantity of shot that is lost from the system is relatively small.

Since this is an outdoor installation, difficulty was experienced during cold-weather operation owing to a mixture of moist fly ash and shot in the receiving hopper. A small quantity of 300 F preheated air was piped to the top of the receiving hopper to overcome this problem. In addition to keeping the hopper dry, the air helps to keep the hopper purged of fly ash. The same purging air was connected into each lift line to prevent condensation.

Since the shot-cleaning system has been operating, there has been no increase in normal draft loss across the air heaters as shown in Fig. 7. Internal inspections were made after 3 months and 9 months of operation. Excellent cleaning was noted since not one of the 3-in. tubes in each upper cold section was plugged and only a small coating of light dust was seen inside the tubes. Before shot cleaning, these 3-in. tubes had a rapid rate of plugging as indicated by Fig. 7. The area between the upper and lower cold sections was free of fly ash and the 2-in. tubes in the lower section were in an excellent state of cleanliness. This is a very definite improvement over the preceding years and has permitted continuous full-load operation of the boiler. As a result of the performance of the shot-cleaning system, a similar installation has been made on the adjacent boiler at this station.

Application Considerations

The shot-cleaning principle uses a vertical fall of shot to remove ash deposits. The application is restricted to a vertical section of a heat exchanger such as the convection pass containing air heater, economizer, and in some cases the superheater and reheater. Adequate space must be provided beneath the hopper for installation of the shot-cleaning pressure tank on the high-pressure lift systems or the shot valve and venturi accelerator on the light-phase system. A clear space must be provided next to the boiler for a vertical run of the lift line and a clear area is required at the top for installing the necessary disengaging equipment.

The type of shot-cleaning system used on a heat exchanger depends upon the quantity of shot required, the frequency of the lifting cycle and the space below the hopper for installing the equipment. The light-phase shot system has been used mainly on pulverized-coal-fired and oil-fired boilers and on installations where the head room below the hopper is limited. The Hyperflow or the pressure-lift system is used on recovery boilers where high shot rates are required. Both the Hyperflow and the pressure-lift systems are batch type that have a high shot rate flowing to the distributors. The Hyperflow system has the advantage over the pressure-lift system in that the wear rate of the lift line and disengaging cartridge is reduced by the slower moving shot. The pressure lift, on the other hand, uses a lower lifting pressure, but special bends are required to keep wear at a minimum owing to the in-

creased velocity of shot in the lift line. The power requirement for each of the three types of lift systems is about the same for a given shot rate per hour.

Summary

Shot cleaning has many advantages over the conventional cleaning equipment used in boiler sections with temperatures below the ash-softening temperature.

1. The same quantity of shot will clean the entire vertical section with no limitations to the height.
2. Boiler height may be reduced by removing cavities normally required for conventional cleaning equipment.
3. The shot system requires no platforms or galleries around the boiler as does the conventional cleaning equipment.
4. The use of shot cleaning may reduce the aisle space between boilers by omission of the conventional cleaning equipment.
5. The cleaning ability of the shot system is often superior to that of the conventional cleaning equipment.

There are 30 black-liquor recovery boilers being cleaned with a pressure-lift system or a Hyperflow system in the United States. A light-phase system has been in operation at the Higgins Station of the Florida Power Corporation since the fall of 1955. Two more recent installations of the light-phase system are on the Philadelphia Electric Company boilers as previously described. The experience gained on these intial installations has proved the desirability and feasibility of cleaning areas as described in this paper through the use of falling shot.

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1. "Recent Developments in the Use of Pellets for the Removal of Slag Deposits in Boiler Furnaces," by W. F. Cantieri, ASME Paper No. 52-A-163, December 1952.
2. "New Developments in Cleaning Recovery Boilers," by P. H. West, *Tappi*, vol. 39, May 1956.
3. Hyperflow is a trade name of a conveying system patented by Union Oil Company of California.

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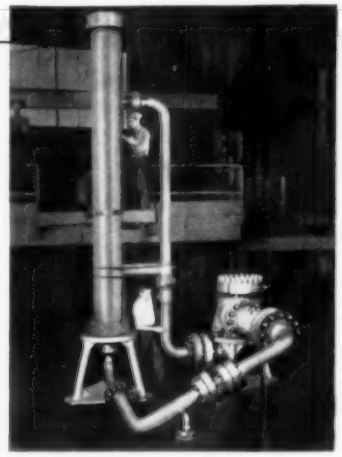

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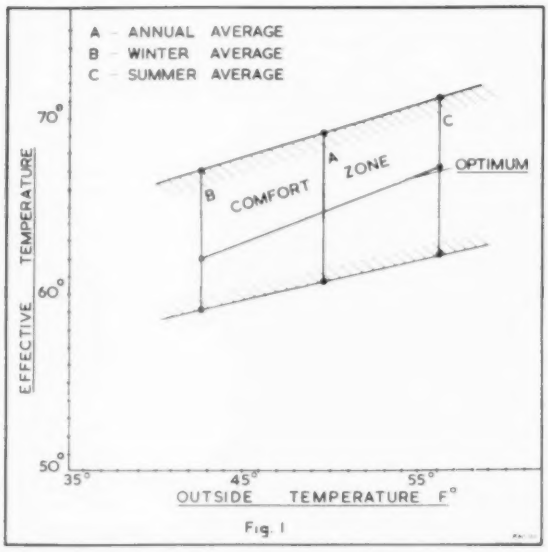

Fig. 1—Comfort zone used in "Heating and Ventilation in Factories," H.M.S.O. 1952 will satisfy at least 50 per cent of a group of normal people

By A. G. KELLY, B.E., A.M.I. Mech.E.*

Electricity Supply Board of Ireland

The Efficient Ventilation of a Steam Power Station

This paper draws attention to the advantages of ventilation to give maximum plant efficiency consistent with comfortable environment for personnel. In many plants the mechanical engineer is primarily concerned with the plant while the civil engineer is concerned with the buildings; neither realizes the effect which the work of the other has on the degree of comfort provided at operating stations and on the operating efficiency of the plant.

POORLY ventilated stations fall into two categories—those which have virtually no ventilation at the operation stations and those where the volume of cold air allowed up through the building is excessive.

As a standard of comfort Fig. 1 is used; this applies to the particular climate being considered in this article. The effective temperature depends on air speed and radiant heat as measured by a globe thermometer. This standard of comfort is that used in "Heating and Ventilation in Factories," H.M.S.O. 1952. It is claimed that this "comfort zone" will satisfy at least 50 per cent of a group of normal people.

Personnel Comfort

Desirable factors for comfort are that air movement should be provided throughout the building and that the higher the temperature and/or radiant heat, the higher the air movement desirable.

In a power station, quantities of heat are given off from the plant installed—boilers, turbosets, motors, piping, and this increases the temperature of the air in the building to a value depending on the heat loss from the building and the scheme of ventilation used. Firstly, the heat given off depends on the efficiency of the insulation on the plant and it is here assumed that the economic thickness of insulation is applied. Also the heat given off is affected by the finish of surfaces and this should be remembered when painting the boilers, turbosets and auxiliaries. As an example, aluminum paint which is suitable for use on surfaces up to about 400 F. will reduce the radiant heat loss by upwards of 10 per cent as against normal oil paints.

Secondly, the quantity of heat given off depends on the air movement across surfaces; the temperature of the air drops with increased throughput but the total heat given off rises.

If an environment is not comfortable this can be for any one or combination of a number of reasons—the air temperature may be too high; the relative humidity may be too high; radiant heat may be excessive or air movement may not be sufficient. In a power station it is a simple matter to keep the temperature as high as desired by reducing the air flow; the problem is to make the temperature lower or to alter the air movement of humidity to compensate for high temperature. It is possible to take in the air for use in the boiler fans at a

* Power Station Design Engineer.

low level and use it at boiler top level; in this way the relative humidity of the air is gradually reduced as the air rises with a compensating effect for the rise in air temperature which takes place.

In this analysis for all variations of ventilation tested, the maximum wet bulb temperature at operating floor level is 65 F and in the building at any height 72 F with an outside relative humidity of up to 88 per cent.

At high temperatures the humidity is the factor which has the greatest effect on comfort.

While Ireland has a moderate climate in Summer (average of 56 F) the relative humidity for the year averages 85 per cent; in case 3(c) for example, humidity was 84 per cent outside, 50 per cent at operating floor level and 27.5 per cent at boiler top. This drop in humidity compensates for the rising temperature to the tune of 5 F at operating floor and 8 F at boiler top.

Typical Plant Oversights

The radiant loss from large industrial boilers is such that if copious ventilation at boiler top level is not employed that zone would be unbearably warm and stagnant. In the older installations, see Fig. 2(i), the forced draft fans are at basement level and draw their air supply from the outside through doors at that level. As a consequence, it was found necessary to install roof louvers to take away the excess heat from the top of the boiler house by natural ventilation due to the chimney effect. At the same time the engine room, which is separated from the boiler house by a dividing wall, which was originally supplied with extraction fans in the roof but no proper method of air supply to pass over the hot surfaces, was so unbearably warm in summer that a cold air plenum system was installed. Thus the advantage of having at no expense the boiler combustion air fans to ventilate the complete building was overlooked. As manufacturers improved their designs, air was taken from roof level to take advantage of the higher air temperature but the open roof louvers remained as a relic of the older scheme. It was probably argued that as there was a vast quantity of hot air flowing from the roof louvers, if these were dispensed with conditions would be unbearable. The mechanical engineer remained concerned with the design of the boiler unit and the civil engineer with the design of the house, but neither of them realized the effect that the work of the other had on his own. The boiler house was cold and drafty except during hot weather.

A second example shown in Fig. 3(d) is where there are very amply dimensioned roof louvers (adjustable or non-adjustable) with fan suction from boiler top level; there are, however, no openings of consequence at low level in the station and in any but the coldest weather conditions become unbearably warm. Hot air rising from the plant passes out through the roof louvers and cold air enters at the points directly over the fan suctions. The air temperature at the inlet to the fan is lower than that at operating floor level. Ventilation depends on leakage into the building and is inadequate.

A Suggested Ventilation

The scheme of ventilation here proposed uses the chimney effect produced by the height of the station and the suction produced by the fan sucking air for combustion to ventilate the boiler house. In effect, air conditioning is attained without the installation of any equipment. The adoption of such a scheme at the planning stage costs very little, as the elimination of roof louvers will balance the costs, whereas if the station is already constructed with inadequate ventilation it may be costly to make alterations.

It is interesting to note that air flowing in through openings does not flow directly upwards by the shortest and easiest path to the fan suction but moves via the hot surfaces.

It is better to provide adjustable louvers for air inlet because if this is not done doors are left open, particularly those of the roller shutter type, once it has been found necessary to open them on one occasion to provide a greater measure of comfort. The custom of leaving doors open is habit-forming and should not be allowed.

Air movement is controlled and marshalled by allow-

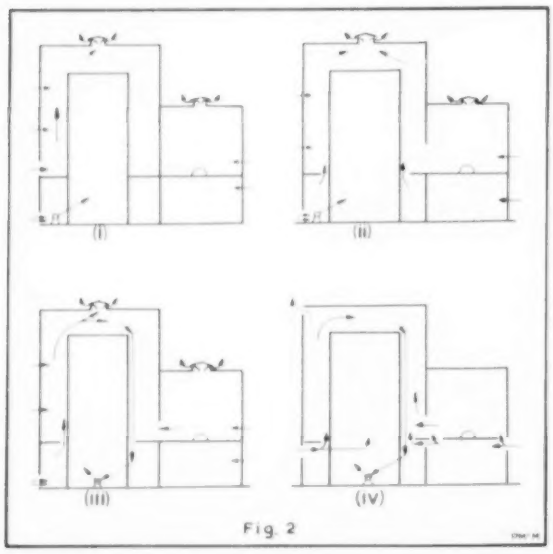

Fig. 2—Four schemes of ventilation of a power station. (iv) is the optimum

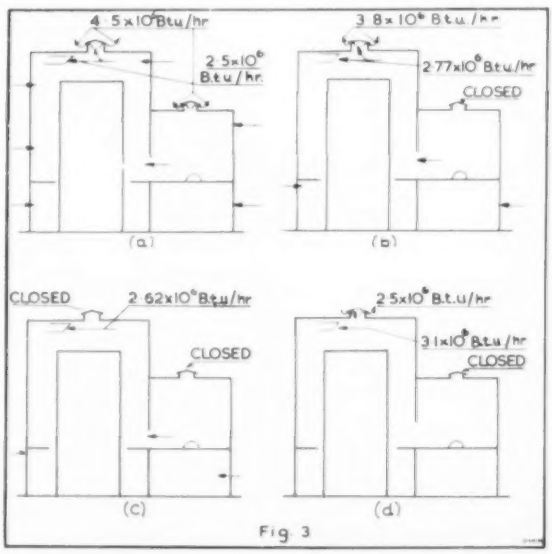

Fig. 3—Test results on a station with 60 mw of plant in service

ing the required amount into the building through adjustable louvers over head height in the basement and letting the air rise through the building, thus providing ventilation without drafts. In this way compensation for high radiant heat and air temperature is effected. The air movement upwards near the boiler casing and through open columns was 4.5 ft/sec on the average for the test later described in Fig. 3(c). The air changes per hour vary from 1 to 8 depending on the plant in use and amount allowed to cross the engine room, which is sufficient. Fresh air is constantly entering at the bottom of the boiler house and engine room and stale air being removed from the top of the boiler house. For maintenance at boiler top level or for off load ventilation where gases accumulate a limited number of opening windows are provided at wall top.

Thus the optimum scheme from the point of view of comfort is one where (1) radiant heat is stemmed by the application of insulation and some suitable paint, (2) relative humidity is lowered with increase in temperature, and (3) air movement is controlled and directed to points where required.

It will later be seen that this scheme can also approach the optimum for plant efficiency.

Efficiency

The provision of a scheme of ventilation which will allow the operating staff to keep efficiency at a maximum is desirable. Power station operating efficiency is of such importance that it is worth while keeping the efficiency at the highest value, consistent with comfort.

A brief summary of the familar schemes formerly used will help in appreciation of the problem. In Fig. 2 are shown four schemes of ventilation.

There are several factors involved and some are interdependent. As stated above the greater the flow of air allowed through the boiler house or engine room the greater is the heat taken from the boilers, turbosets, piping and auxiliaries; on the other hand, if sufficient air flow is not provided, conditions become unbearable.

Case (i) shows a scheme usual in older installations where no attempt was made to provide either comfort or efficient ventilation. Here cold air is drawn directly to the boiler fan with consequent loss of the advantage of using warm air.

Cases (ii) and (iii) are commonly employed. (ii) has the fan suction low down in the building while (iii) has it at boiler house top level. Case (ii) has the disadvantage that in Summer, when the lower openings must be kept open for cooling of the boiler house, the fan suction cannot take advantage of the heated air passing to waste through the top openings. Case (iii) has this extra advantage. Windows are indiscrimately used in (i), (ii) and (iii).

Case (iv) goes a step farther; air to the fans is drawn from the engine room and from the warm air rising up through the boiler house; in this way forced ventilation of the engine room is achieved without great heat losses occurring. In addition, loss via the roof ventilators is avoided. An appreciation of the factors involved is essential for the optimum operation of this scheme and the test figures detailed later are a help. Adequate ventilation of all operating stations can be achieved in these climates with no free exit from the boiler house or engine room at high level, by drawing air through both buildings to the fan suction. It is not necessary to have personnel stationed over operating floor level; these areas are visited for routine checking.

It is not proposed to discuss here the economics or operational advantages of taking air from boiler top level in stations where the forced draft fans are in the basement; that aspect has already been amply covered in several papers. Sufficient it is to say that most stations being now built take the air from the boiler top.

The heat given off from plant can be increased or decreased by altering the scheme of ventilation. As an indication of this, consider (a) and (c) of Fig. 3; (a) has a heat from engine room and boiler house equipment of 13.0×10^6 Btu/hr whereas case (c) has 9.80×10^6 Btu/hr with the same plant in use—test results below.

Design For Ventilation

Too often heat balances are drawn up by assuming a value for radiation losses. In the tests carried out at average annual conditions the net radiation/convection losses varied by 0.13 per cent. When outside air temperature and speed, and the door and window openings and number of units in service vary, the radiation loss per unit will change and it should not be left to guesswork. The calculation of this item will account in part for the mysterious fashion in which unmeasured losses vary from test to test. The task of measurement is greatly simplified by the adoption of the scheme outlined above.

The problem of ventilating power stations has been approached from the point of view that the heat loss from the surfaces of the boiler plant of the type and size installed is 0.5 per cent, of the turboset 1.5 per cent of output, and of auxiliary plant is 5 per cent of output. From this heat loss the size of louvers and openings is designed. This gives, however, a very simplified and misleading answer.

It is startling to consider the quantity of waste heat that is emitted unnecessarily from the roofs of power stations, and indeed from many other buildings. It is appreciated that to the engineer this loss will be obvious once it is seriously considered.

To get the full advantage from the gain in cycle efficiency to be had by using the optimum scheme of ventilation the boiler must be designed for the appropriate air inlet temperature to the forced draft fan; the air heater surface must be sufficient to take advantage of the hotter air.

The application of the scheme here suggested will have an effect on the efficiency of existing stations depending on several factors, e.g.:

(1) If the air heater uses no hot air recirculation, then raising of the air inlet temperature to the forced draft fans will raise the flue gas temperature and increase the fan power required, with a reduction in the net benefit.

(2) If hot air recirculation is being employed to keep the air heater metal to an economic temperature where corrosion is not too rapid, then by raising the air inlet temperature to the forced draft fan this recirculation is reduced; the flue gas temperature remains the same and a gross gain in efficiency due to the hotter air, the zero roof louver loss and the lower fan power needed accrues.

Test on a Power Station

It is relatively simple to effect a heat balance to show where the heat loss from the plant in the station goes.

TABLE 1—FACTORS FOR LOSS IN BTU PER HOUR, PER SQ FT PER °F

Material	Loss in Btu
Walls	
Brick wall 4½ in. thick with ½ in. plaster	0.57
Brick wall 9 in. thick with ½ in. plaster	0.43
Brick wall 13½ in. thick with ½ in. plaster	0.35
Brick wall 18 in. thick with ½ in. plaster	0.29
Brick cavity wall 11 in. thick, 2 in. air space, plastered ½ in.	0.30
Brick cavity wall 15½ in. thick, 2 in. air space, plastered ½ in.	0.26
Concrete wall 4 in. thick	0.64
Concrete wall 8 in. thick	0.47
Concrete wall 10 in. thick	0.41
Asbestos corrugated sheeting	1.15
Corrugated iron ⅛ in.	1.20
Windows	
Single window	1.0
Double window	0.5
Skylights	1.2
Floors	
6 in. concrete on earth	0.20
Concrete on earth with wood blocks	0.15
Ceilings and Roofs	
Flat concrete 6 in. thick, finished asphalt	0.57
Flat concrete 6 in. thick, finished asphalt and 1 in. cork	0.21

The quantities, temperatures and direction of flow at each temperature aperature are measured; the heat loss calculation through the walls, roof and floor of the building is a standard calculation and figures are available for all normal constructional materials. The heat loss for some normal constructions used in power stations is reproduced in Table 1.

The effect of the sun's heat in Summertime is considerable where glazed construction is employed. In the station tested it is not a factor.

The heat loss from the surfaces of the plant can be computed either directly or indirectly; the direct measurement is achieved by measuring the surface temperature of each increment of surface and calculating the heat loss from each; the sum of these losses gives the total. This method raises many problems, e.g., the co-efficients of heat transfer and emissivities have to be chosen, the ambient air temperatures at each increment of surface found and the total area of the surfaces of all plant with its interconnecting ductwork and piping found. The indirect method is here employed where the radiant loss is measured as the sum of (*a*) the heat to the forced fan suction; (*b*) the heat loss through walls, roof and floor; and (*c*) the convection loss through openings at a high level. Of these three the second presents a possibility of inaccuracy comparable with the direct method of measurement but in this case the heat involved is a fraction of the total loss and the possibility of error is correspondingly less. Outside temperatures are taken as the zero of heat gain.

The indirect method is rapid and thus lends itself to answering which of several methods of ventilation gives the lesser loss and this is basically what is of interest.

The station selected was chosen for these tests because various schemes of ventilation could be attempted by virtue of the large number of opening windows and adequate openings in all floors.

The engine room housed three 30 mw turboalternator sets and the roof is fitted with vents which can be closed off. The usual large shutter door is fitted in the engine room and this proved useful in varying the amount of air allowed into the engine room.

The passageway from engine room to boiler house is open along its entire length over operating floor level.

The boiler house houses four B&W type FH 200,000 lb/hr boilers; the roof is fitted with conventional louvers which, on test, are not very effective in aiding the chimney effect in the building because when a strong wind is blowing it enters on one side and blows out the other thus greatly reducing the effective area. These louvers were, for part of the test carried out, blanked off to simulate conditions with shut or no louvers.

Throughout the test three boilers and two turbosets were on load—the last boiler and turboset being under construction.

A series of tests was carried out to show the difference in heat given off by plant and the degree of comfort attainable with variations in the scheme of ventilation.

A test was also carried out to show the effect of closing off all openings but the roof louvers. In this case temperatures at operating floor level reached an effective temperature of 78 F and after a time personnel complained of lack of ventilation; conditions were clearly unbearable.

Results

Fig. 3 is a synopsis of a series of tests carried out at 90 per cent boiler load while outside temperature, wind speed and humidity were very close to the annual average. The total heat given off from plant varied from 13.9×10^6 Btu/hr to 9.8×10^6 Btu/hr depending on the scheme used.

Fig. 3(a) shows conditions with the roof louvers open and openings in the boiler house of 320 sq ft below operating floor and 305 sq ft above it and 650 sq ft in the engine room beneath operating floor and 175 sq ft above operating floor. Conditions were comfortable at operating stations but the total heat loss from the plant was 13.0×10^6 Btu/hr and of this 7.5×10^6 Btu/hr returns to the fan suction of the three boilers.

Fig. 3(b) shows the optimum scheme with open roof louvers. Openings of 140 sq ft beneath the boiler house floor are the only deliberate openings provided; leakage into the engine room kept conditions comfortable. In this case the heat loss adds up to 13.90×10^6 Btu/hr and of this 8.31×10^6 Btu returns to the fan suctions.

Fig. 3(c) shows the position when the roof louvers are shut off. A considerable drop in heat loss is now effected and the requisite number of openings can be allowed to provide ingress of combustion air without providing excessive heat loss from the plant.

In this test 280 sq ft was found to be adequate. This showed the highest efficiency compatible with comfort. The heat loss from the plant was 9.8×10^6 Btu/hr and of this 7.86×10^6 Btu/hr returns to the fan suctions; an increase of 15 F in outside temperature increased the temperatures by 4 F at boiler top level and this scheme is practicable for Summer and Winter operation in these climates. It is more efficient than a boiler house operated with ingress via the roof only, as in Fig. 3 (d).

Fig. 3(d). Here flow of air was measured in through the roof louvers to the fan suction at the same time as hot air escaped elsewhere through these louvers. The overall loss in that case was 13.7×10^6 Btu/hr of which 9.3×10^6 Btu/hr returns to the fan suctions; conditions were well outside the comfort zone.

The difference in net heat loss from the station build-

ings between case (a) and (c) is 3.60 × 10^6 Btu/hr which for the particular test done represents 0.43 per cent of the cycle efficiency. In the station tested the hot air recirculation on the air heaters was employed; thus the adoption of (c) resulted, in addition, in less hot air recirculation and a slightly lower fan power. The losses are a higher percentage at lower loads as the heat given off does not fall off in proportion to the load decrease. This gain is very real and is one which will not be minimized through aging of the plant in the station. This scheme is thus attractive to the boiler maker who can quote a higher efficiency when the ventilation scheme is stipulated; it is also of prime importance to the boiler user as, for example, in the case quoted above where in the station in question 0.43 per cent efficiency represents approximately £67,500 capitalized saving over 25 years' use. There are other advantages, such as less clogging of air heaters by virtue of having the air entering the fans at the highest practicable figure, or alternatively, smaller air heaters required to prevent clogging in winter time; the former is better than raising the air temperature by hot air recirculation because streaming is difficult to prevent in the latter case.

Economic Comparison of Building Materials and Outdoor v Indoor Plants

From these tests it is clear that an outdoor plant is not as attractive as might at first sight appear. The loss of 5.5 × 10^6 Btu/hr would be greatly exceeded where free air circulation is allowed at the surfaces; the average wind speed at the station tested is 10 mph in winter and 8 mph in summer; no saving or advantage by using warm air at the forced draught suction is possible. Even the difference between 5.5 × 10^6 Btu/hr and 1.9 × 10^6 Btu/hr, which is but part of the saving possible by virtue of having an enclosed house, is sufficient of itself to make housing of such plant the more economic; the advantages which in these climates are virtually a necessity are thus economically available.

Plant with far greater insulation would thus be required for economic outdoor use and it is probable that an air encased boiler casing would be necessary in these climates to make the proposition more economic than a housed plant.

The economic comparison of various forms of building materials is also important. Power stations are built in a variety of materials varying from glass-clad walls to brickwork construction. As a comparison the total heat loss from the station tested was, in Fig. 3(c) for example, 1.9 × 10^6 Btu/hr at average annual conditions—the station being constructed of concrete walls. Had this station been glass-clad from 9 ft above operating floor level upwards, the heat loss would have been 3.0 × 10^6 Btu/hr. Thus the heat loss from the building must be considered in choosing the building material. The price difference between the cheaper and the more durable forms of construction is narrowed down and the latter with its long life and low maintenance costs becomes more attractive than when considered on initial cost only.

Summary

A scheme of ventilation of a steam power station is developed which gives comfortable conditions at all operating stations and which, at the same time, gives the lowest heat loss from the building. Results of tests done on a station with varying schemes of ventilation are given; these show a wide variation in heat emission from plant depending on the scheme used. Schemes of ventilation normally used heretofore are discussed.

Acknowledgment

The author wishes to express his thanks to the Electricity Supply Board of Ireland for permission to publish this article, and to those in its employ who furthered the carrying out of the tests in November 1956, particularly Messrs. J. McDonald and K. B. Moloney.

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Heating and Air Conditioning Exposition Announces Show Plans

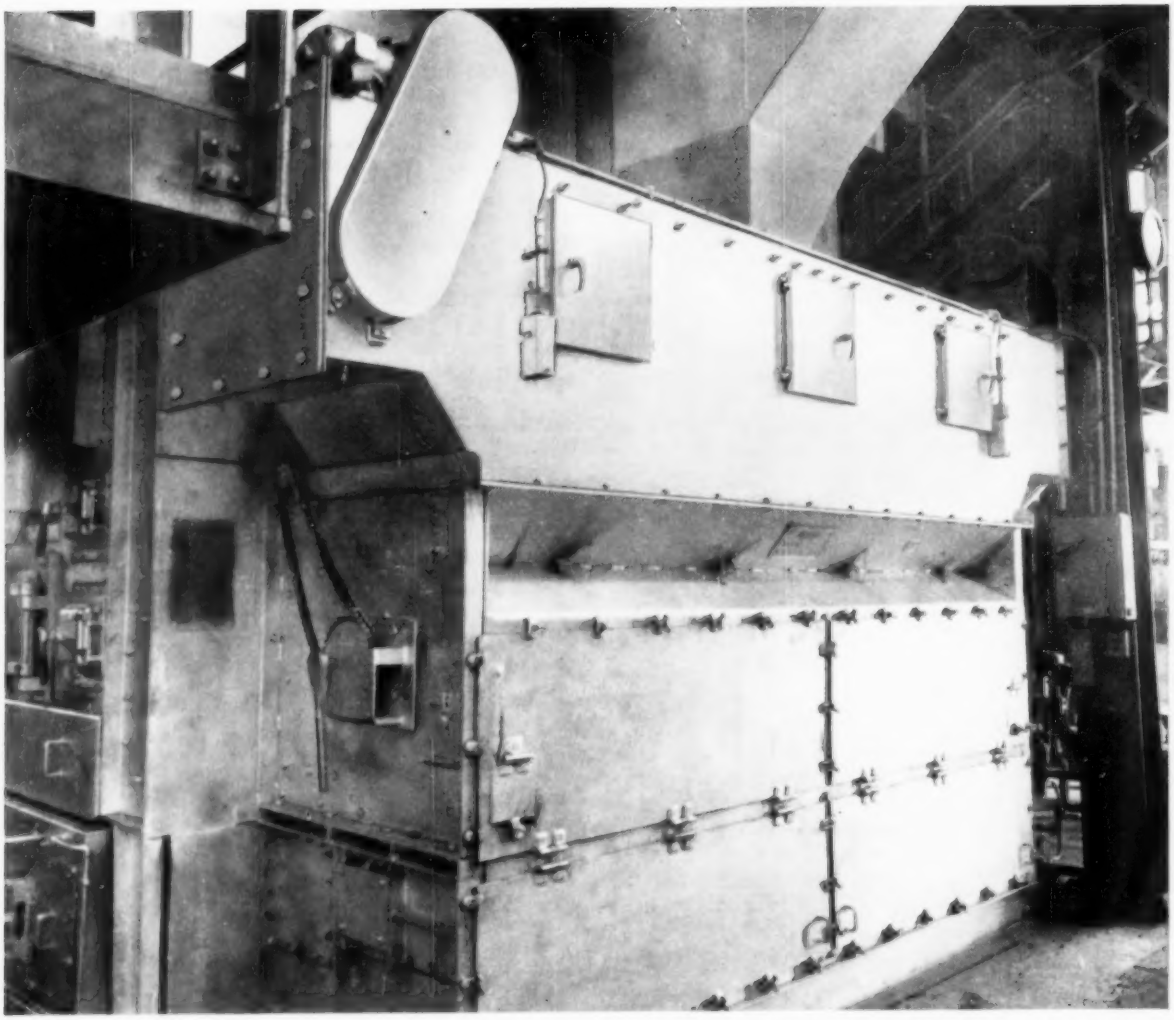
Air moving equipment will highlight the 14th International Heating and Air-Conditioning Exposition to be held in Convention Hall, Philadelphia, January 26–29, 1959.

Air moving equipment on display will range from examples of the latest developments for highly critical applications to new and simpler forms intended for everyday uses. It will include means of air propulsion from fans to centrifugal blowers. It will also include such means of distribution as ducts, dampers, mixers and diffusers. Controls for air movement and quality will be represented in detail.

One of the most advanced fan designs to be exhibited was developed originally to fulfill the critical requirements of the nuclear-powered submarine. It is equally suitable for aircraft applications and will find special uses in applications on the ground. Its construction features higher air pressures, higher efficiency and lower air-borne noise, low structure-borne vibration and light weight. All these advantages have been combined in its design.

Special features will distinguish almost every display of fans and blowers. A line of tubular centrifugal fans and blowers has been augmented by a low-speed vaneaxial design whose low rate of revolution (357 rpm) makes for exceedingly quiet performance. A fan-coil unit has been developed that will reverse the direction of flow to take advantage of natural currents of air, for heating or cooling, according to the state of the weather. A new package fan has been produced for general industrial uses with intent to minimize installation and service time.

Specialization in air moving equipment has been carried into components. A line of propeller blades has a range of sizes from 6 in. to 48 in. diam. A line of wheels and blowers includes duct blowers that will suit practically all installation requirements, including vertical and horizontal mountings.



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ANNOUNCING

The Stock Equipment Company Non-Segregating Layer Loader is a new and positive way to insure even stoker fires. This mechanical distributor mixes separated fine and coarse coal, removing the bad effects of bunker segregation. The mixing action of the layer loader also makes tempering more uniform.

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Inside the dust-tight housing of the S-E-Co. Layer Loader is a small, bottomless larry car that is driven back and forth across the stoker hopper. Each time the car passes beneath the downspout, an automatic coal valve allows coal to fill the car. As the car continues to traverse the hopper, the coal flows out the bottom, effectively mixed and distributed.

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the Stock Equipment Company Non-Segregating Layer Loader

ASME Annual Meeting Highlights—I

As we went to press the 1957 ASME Annual Meeting was just getting underway. The program featured as many papers as did last year's, about 300 in all, and required the facilities of both the Hotel Statler and the Hotel Sheraton-McAlpin for the week of December 1–6. In our January issue we shall report on Banquets and new officers along with abstracts of those papers held to be of interest to our readers and not covered in the following.

DIGITAL COMPUTERS

Elmer S. Monroe, Jr., of E. I. du Pont de Nemours & Co., spoke on "The Application of Computers to the Small Power Plant." The application of computers to large power stations of the central utility type is an established fact. The potential applications in the future to large power stations have been well charted. This paper shows (1) there are many areas where automatic computers can be applied economically to the small power plant; (2) programming costs for automatic computers can be minimized by avoiding complicated calculations that either do not increase the solution accuracy or that include nonsignificant factors; (3) thinking in terms of computer programming can often lead to improved ways of performing existing tasks with simple calculating equipment such as desk calculators or slide rules.

Large central stations may individually justify improved engineering techniques involving computer application since the reduced investment costs may be appreciable. The small station, on the other hand, has exhibited a decided trend toward the use of "standard" and "package" components as a method of reducing investment. The very number of "package" boilers being sold to industrial plants points out an indirect application of computers. The early application of computers by either equipment manufacturers or by central engineering offices to optimize design of standard units and systems by furthering such efforts of systems engineering as have recently appeared in the literature will go far to reduce investment costs for the small plant.

As an effective tool to implement power conservation, some industries use "power consumption standards"; "power generation standards"; "utility budgets," etc. These have proved effective yardsticks by which to measure performance of various operations or departments, and if properly conducted are very effective in reducing costs. The application of computers to these programs can offer the greatest economic attraction to the small power station.

Computing periods for standards are frequently of a month duration and may require several additional weeks of preparation. A significant loss may have occurred for an extended period before supervision is advised. The rapidity of computation by a computer offers the opportunity to reduce standard periods to a week, day, or even to almost instantaneous periods. Significant losses can be located rapidly before they accumulate in magnitude. Optimum loading of equipment can be specified at a time when operators can profitably use the information.

Alexander Zabludowsky of Stone and Webster Engineering Corp., stated in his paper "Generalized Steam Power Plant Heat Balance for Digital Computer Application" that most advantageous for solution on a computer are highly repetitive problems involving a large amount of computation and, the authors commented, many such problems are poorly defined in terms of a generalized solution procedure, which is the prime prerequisite for an efficient computer program. One such problem often encountered in engineering work is the steam-power-plant heat balance.

Steam-power-plant heat balances consist of determining the conditions at many points in the steam cycle from various turbine data and throttle conditions. From these results, the kilowatt output of the unit is determined. The complexity of the solution is found in the large variety of turbine cycles and the variety of components involved.

The basic conditions that have to be determined are flow, pressure, temperature, and enthalpy at various points in the cycle which is composed of a number of turbines, reheaters, condensers, pumps, air ejectors, gland-seal condensers, heaters, evaporators, steam air heaters, jet coolers, deaerators, attemperators, blowdown flash tanks, and valves. All these components may be interconnected in any number of ways resulting in an almost infinite number of cycle configurations.

In the hand solution of a heat balance, about the half the time is spent in collecting the necessary data for the solution. The solution itself is composed of several complete balances each for different throttle and back-pressure conditions. Owing to the large amount of time spent in gathering data, the general statement of the balance should require minimum additional time for this task.

The author presents a listing of the items to describe a given power-plant heat cycle. Such a representation is primarily useful in application of the problem to a digital computer. The generalization employed may be extended, then, if it is held necessary to include more components. This process would only increase the number of possible items on the lists. The system of lists itself is sufficient to represent any power plant configuration provided a sufficient variety in items exists.

The method described has been employed successfully to solve steam-power-plant heat balances on the IBM 650 computer. In this application steam-table functions were represented in polynominal form in the computer. For a sufficient convergence, it normally requires, de-

pending on the closeness of the extraction flow approximations, two iterations through the heater cycle, said the author.

"Applications of Computer and Model Studies to Problems Involving Hydraulic Transients" was presented by **I. W. McCaig** and **F. H. Jonker,** H. G. Acres & Co. The improved tunneling methods of recent years have now made it possible to construct large power tunnels which supply water to a number of turbines. This sometimes results in a system of penstocks and junctions to which it is not possible, when calculating water-hammer pressures, to apply the simplifying assumption of an equivalent pipeline of constant diameter. In projects where a surge tank is required, the greater tunnel diameter has considerably increased the capital outlay on the tank.

For the economic design of such large hydroelectric projects the applications of water-hammer and surge-tank stability theory have had to be extended and the increased volume of computational work has required the employment of digital and analog computers. In some cases when the exact form of differential equation for the hydraulic transient is not known, resort has been made to experiments on dynamically similar models.

This paper deals, first, with the application of a digital computer to water-hammer calculations on a complicated penstock layout. It then shows how problems dealing with the stability of a surge tank can, in many cases, be clarified by the use of an analog computer and, in cases where extremely variable hydraulic losses unduly complicate the hydraulic transients, an electronically controlled model may be used to effect economies in surge-tank costs.

Model Testing

"Use of Models for Studying Pulverized-Coal Burner Performance" was the subject of **G. C. Whitney,** Foster Wheeler Corp. The author described what was observed in the first and last of the many models which were tried out. The first and most important observation was that no matter what the distribution of the dust in the conduit entering the burner, all of the dust was immediately centrifuged against the perimeter of the scroll and made from three to six complete rotations within the volute before entering the burner body proper. All coal leaving the volute inlet leaves in a narrow band and proceeds as a "standing rope" or spiral to the outlet. The amount of lead of this spiral determines the angle at which this "rope" leaves the burner, varies with inlet conditions, and can be changed readily. With coal concentrated in a region, the dust splatters against the bottom of the volute, thus losing energy, and is more liable to settle out in the volute inlet. When this happens, the rotation is destroyed, and settling out continues until complete stoppage occurs or a high-velocity passage develops and maintains itself with very poor dust distribution at the tip of the burner. Of course with multiple burners connected to a single distributor, stoppage is the more probable end result. When dust is concentrated at other areas of the inlet there is less "splattering" and less tendency to settle out in the volute at reduced ratings. Many attempts were made to disperse the standing rope. Actually the only thing that worked was a low baffle at right angles to the motion of the rope. Unfortunately the rope reformed almost immediately. Succeeding baffles continued the dispersion until the conical section was reached. Here the rope re-formed and no arrangement of baffles of "hurdles" could disperse it.

Once the pattern of performance was spelled out, the steps required for cure became almost self-evident. The offset of the volute inlet was increased so that no matter where dust is concentrated in the approach conduit it will approach the volute at a not too unfavorable approach angle. This greatly minimizes the tendency for dust to settle out at reduced ratings. The multiple random baffles have, for convenience, been grouped into continuous axial bars. A cylinder-and-cone combination has been modified into a single continuous cone. It has been found that the length of the conical section itself is not critical. However, the position of the ends of the axial bars with respect to the ends of the conical section is quite important.

The effect of the bars is to take the standing rope and break it down into equal streaks which are elements of the cone. These streaks seem to be maintained and equalized by the continuing rotation of the primary air If the bars are continued to the tip of the cone the streaks can be clearly observed well out into the furnace. If the bars are stopped off short of the tip these streaks become dispersed.

These are the basic principles of proportioning which have been applied to several sizes of burner with, thus far, very successful results. Unanticipated secondary advantages have also resulted from the improvement in coal distribution. With consistently uniform dust distribution it has become possible to reduce the amount of secondary-air rotation. This makes for a less bushy flame, reduces the incidence of side-wall flame impingement, and also lowers windbox pressures.

R. W. Curtis and **L. E. Johnson,** The Babcock & Wilcox Co., gave their version of "Use of Flow Models for Boiler Furnace Design." As they saw it, much of the work in boilers and furnace design concerns the determination of the shape and size of ducts, pipes, and enclosures that will produce efficient flow of air, gases, and fluid fuels to and through the system. It is now well recognized that the flow-distribution patterns of furnace gases affect the efficiency of combustion, the heat transfer to furnace surface, the amount and location of furnace and superheater fouling, and the rate of deterioration of furnace and superheater surface due to corrosion, erosion, wastage, and so on. Except for simple configurations, the prediction of these flow patterns is impractical or impossible by ordinary analytical methods, and even though it might be possible to write differential equations for certain flow conditions, it is not always possible to solve them. The use of scale flow models is an excellent method for solving flow problems.

A considerable amount of literature is available on the general theory and design of models, and a number of articles have been written concerning the use of models to solve specific problems. Relatively few of these, however, relate specifically to furnace design. This paper deals primarily with the use of models by the authors' company to solve flow problems encountered in boiler-furnace design. It includes a description of the types of models used, methods of testing each type, the particular

advantages and applications of each type, and, as a specific example, the use made of models in establishing the furnace arrangement for the first commercial supercritical-pressure steam generator now installed and operating at the Philo Plant of the Ohio Power Company.

"Power Heat Balance Considerations in Design and Operation of Industrial Plants" was the contribution of **J. I. Hudson,** E. I. du Pont de Nemours & Co. In designing an industrial plant for maximum economy or return on investment, it is logical, Mr. Hudson claimed, to start with a layout which will obtain minimum investment consistent with the basic requirements of safety, working conditions, and product quality. Any deviation from this base that will increase the overall return on investment without sacrificing standards of safety, working conditions, or quality, may be acceptable for incorporation in the final project design. An example of this type would be an expenditure of additional capital for automatic control systems to secure a substantial reduction in operating labor cost.

With such considerations in mind, project schedules usually are shortened toward the practical limit which requires that much of the basic data development, actual design, procurement, and construction be carried on simultaneously. A time schedule for a typical new plant project was shown.

During the early stages of basic data development and design, numerous economic evaluations are needed to establish optimum conditions for highest return on investment. In consideration of the advantage of completing a project in a minimum of time, minor sacrificies in accuracy and thoroughness of the economic evaluations can be tolerated.

Whereas the overall performance of an electric utility plant can be computed with remarkable accuracy and expressed in simple terms, such as net heat rate, the problem on the average industrial power plant is much more complicated. There are many good systems in use for measuring power-plant performance and controlling operating cost, and the one the duPont Company uses has been found very effective. The objectives of their system are (1) to provide management with a measure of overall performance so that any change for better or worse can be detected easily and quickly; (2) to spotlight preventable losses and evaluate them; and (3) to show the causes of preventable losses and thus aid in correcting them.

Most industrial power plants export several commodities, such as steam, electricity, refrigeration, compressed air, and water. Often steam is supplied at several pressure levels of quality. The performance standards used on du Pont power plants provide a measure of overall efficiency, which is expressed as the ratio of standard total dollar cost to actual total dollar cost. The items included in each factor of "total dollar cost" are fuel and any utilities, such as electricity, which may be purchased from outside sources. Operating labor, maintenance labor and material, miscellaneous supplies, and fixed charges are handled separately.

Standard total dollar cost represents the minimum combined cost for fuel and purchased utilities which should be incurred for a given set of exported loads and uncontrollable operating conditions. In setting up the standard, allowance is made for scheduled maintenance which occasionally takes the most efficient units out of service.

J. H. Chesters, the United Steel Companies, Ltd., opened with the paper "The Aerodynamic Approach to Furnace Design." It was not until 1945, the author reported, that a systematic study was begun of flow patterns in models and furnaces and their relation to mixing, flux deposition, temperature distribution, and refractory wear. The story of the early developments has been told in a paper on "The Growth of an Idea." It was stressed that long-term studies demand a fundamental approach since otherwise even such an elementary thing as recirculation remains unexplained and, therefore, uncontrolled.

During the last decade a large number of research groups have started work in this field and a substantial literature is now available. Whereas the initial hope was to get a rough idea of furnace conditions from models, it has been shown that given sound similarity, data quantitatively applicable to actual furnaces can be obtained. This can be illustrated by recent publications on open-hearth and reheating furnaces. The similarity conditions are by no means simple, but the general relationships, as summarized for example by Johnstone and Thring are now fairly well established.

Furnaces are basically refractory boxes into which streams of fuel are injected. A first essential to understanding flow pattern and mixing in such systems is, therefore, a study of the behavior of free jets in air.

Such studies have been run. Simple shoe-box like furnaces have been erected to study cold air flows and jet patterns. Space does not permit detailed discussion of the intermediate stage, viz., hot models. Strange though it may seem, it is more difficult to achieve similarity between the hot models and working furnaces than between the latter and cold models. The explanation of this observation is far from simple but is connected, for example, with the fact that both cold models and actual furnaces tend to work at substantially uniform temperature, whereas far bigger differences are often found in hot models, due both to the large weight of brickwork compared with the size, and the fact that one-way firing tends to result in a comparatively cold entry end unless very hot preheated air is available.

The most complete comparison so far reported is that given in Iron and Steel Institute Special Report 59, where air models, using hot air as the jet fluid, were employed to study the effect of such factors as burner angle and position on mixing pattern. It was shown, for example, that even where the furnace chamber itself is symmetrical the mixing pattern may be strongly asymmetrical, due to uneven velocity distribution within the air uptake. Although this limitation should ultimately be removed by attention to entry conditions, it has been shown that much improved symmetry can be achieved meantime by displacing the single burner toward the front wall or inclining it a few degrees in the same direction.

Another important conclusion from this work was that recirculation is quite substantial, being of the order of 50 per cent of the forward flow. In view of this it may well prove to have an important effect on heat transfer.

A comparison of mixing on the flame axis shows it to be somewhat less in the furnace than in the model under the similarity conditions in use at the time. Since this work was reported, a more detailed study has been made by Holden, in which improved similarity criteria are recommended. Another aspect of the problem, viz., dwell time, has been studied by Peirce and Thring, in this case for pulverized fuel boilers.

In spite of the progress reported, much remains to be done, in particular the relation between flow and mixing patterns must be tied up more specifically than at present with heat transfer along and across the furnace. A substantial step in this direction has already been made by Thring and Smith, their theory having been applied with quite encouraging results in comparing actual and theoretical heat transfer in an open-hearth furnace. It is already proving of practical value in the selection of variables for future trials, enabling, as it does, the probable gain from such radically different factors as oxygenation and increased oil-flow rate to be predicted.

A. A. Putnam and **E. W. Ungar,** Battelle Memorial Institute, supplied the paper "Basic Principles of Combustion-Model Research." This paper first considers the basic assumptions upon which cold-flow modeling of combustion systems is carried out. Next, some applications of modeling to various combustion problems are considered. Finally, the type of results that should be expected from the application of modeling techniques are discussed.

Often more is expected in a comparison of model and prototype results than is expected in a comparison of two supposedly identical prototype units. It would appear that too often a model is made too perfectly. Especially in cold flow models, the warpage, leaking, and other such factors that are expected to develop in prototypes are not present. Furthermore, misalignment of parts found in prototypes, and deviations from design, are not found in many models. It would appear profitable to pay more attention to the use of models to study the effects of expected deviation from design in prototypes.

A typical example often encountered in fluid-flow studies is the comparison of symmetrical and asymmetrical design. In such models the symmetric system often appears to have many advantages. However, the investigator will know that asymmetrical systems are preferred in practice as giving better performance. Why? In one case, imposing expected production tolerances on the symmetric model gave the reason. The performance significantly deteriorated with deviations from symmetry which were far less than expected for production units.

If all these factors have been considered and investigated, then the remaining difference between model and prototype results are a consequence of differences in dimensionless groups of importance in the design. The amount of deviation is an indication of the actual importance of these factors.

Corrosion Causes and Cures

Harold J. Rose and **Richard A. Glenn,** Bituminous Coal Research, Inc., opened a joint Fuels Div. and Corrosion and Deposits Committee Session with the paper "Coal Cleaning in Relation to Sulfur Reduction in Steam Coals." According to the authors about 60 per cent of bituminous coal mined in the U. S. is mechanically cleaned to reduce ash and sulfur and to maintain uniformity of products. The proportion of total sulfur so removed by coal-cleaning processes is small to moderate and varies with different coal beds and localities. The forms in which sulfur exists in coal, the technical limitations to removing them, and the extensive research which is in progress on coal-preparation problems makes up the subject matter of the paper.

When cleaning any given kind and size of coal, the authors warn, an economic limit exists beyond which any further reduction of sulfur or ashis attained only at prohibitive cost. Steam coal is cleaned primarily to remove extraneous impurities resulting from the mechanized mining and loading methods which are used to reduce mining costs. The maximum removal of sulfur from coal by any known cleaning process does not even approach the possible removal of sulfur dioxide from the stack gases after the coal is burned. In other words, the sulfur is far more accessible for removal in stack gases than it is in coal.

Other approaches to the sulfur problem include (a) stockpiling low-sulfur coal for use when severe smog condition are predicted, and (b) placing new electric-utility plants at a distance from metropolitan areas to disperse the sources of stack-gas emission.

The evaluation of "incremental costs" and the benefits of coal preparation in relation to the use of coal by electric utilities was held by the authors to be beyond the scope of this report. Such factors need to be worked out for each individual combination of power plant and coal supply.

B. L. Canaday, Dowell Division of the Dow Chemical Co., appearing on another session delivered a paper "Hydraulic Jetting Tools for Cleaning Heat Exchangers" that to our mind followed along the lines the above paper suggested so that we place its abstract in this point in our report. Cleaning tools, Canaday states, have been developed to utilize high-pressure water jets to remove fouling deposits from regenerative air preheaters and from both shell and tube sides of heat exchangers. These new tools offer several advantages over other cleaning methods. Hydraulic jetting tools provide quicker, more thorough cleaning, and often make possible deposit removal that cannot be accomplished by other methods. Jetting is noncorrosive and in most cases is less expensive than other mechanical cleaning methods. Special jet nozzles have been developed which provide solid streams that retain high velocity for distances as great as 20 ft. These orifices are an important factor in the success of hydraulic cleaning tools. Truck-mounted pumps supply these hydraulic jetting tools with large volumes of water at high pressures. Pumps and orifices of different sizes and capacities are available, so that equipment can be selected to remove deposits effectively.

The author spent some time in describing and illustrating the equipment for this service. The descriptions covered mostly power plant and oil refinery problems but the author felt the principle was the same in each instance.

Abstracts From the Technical Press—Abroad and Domestic

(Drawn from the Monthly Technical Bulletin, International Combustion, Ltd., London, W. C. 1)

Fuels: Sources, Properties and Preparation

Prediction of Fouling Tendencies of Coals. K. Wickert. *Energie* (1958) **10** (July), 267–77 (In German).

The constituents of the coal ash which cause individually or in combination fouling of superheaters are considered, but not deposit formation by molten ash particles. The chemical and physical bases of a method of assessing the fouling tendency of coal are discussed and the two layers formed by the ash constituents are described. Investigations carried out have shown that the most important constituents of the ash are the alkali salts, especially the sodium salts, and the sulfur. Experimental methods for analyzing the following constituents and other properties of the ash are given: (1) water-soluble alkalis; (2) water-soluble calcium and the sulfate ion; (3) total sulphur; (4) solidification of the ash. The results of analyses of Ruhr, Polish, American and English coals are tabulated and from these the fouling tendencies deduced.

Mechanical Handling

Pulverised Coal Transport through Pipes. R. C. Patterson. *Combustion* 1958, **30** (Aug.), 47–57.

Laboratory investigations into pneumatic transport of coal, especially for the selection of exhausters from pulverizing mills, are described. The studies dealt with the performance of exhausters handling air only and a mixture of coal and air, determination of friction losses, prevention of erosion in the pipelines, and the development of devices for measuring flow of coal and air in the pipes, and the prevention of drifting to reduce pressure losses and maintain balanced flow in parallel pipes. The results are presented in tables and graphs.

Heat: Cycles and Transmission

Heat Transfer by Fly Ash Radiation. R. Berlich and W. Pontz. *Energie* 1958, **10** (July), 277–80 (In German).

Equations are developed for calculating the amount of radiant heat transmitted by the incandescent fly ash particles to the furnace walls and an example illustrates their application. The accuracy of the results mainly depends on two factors: an exact knowledge of the amount of fly ash suspended in the gas and a material constant which is to be obtained by measurement.

Heat Emission During the Boiling of Water Below Saturation Temperature in Pipes. I. T. Aladev, L. D. Donodov and V. S. Udalov. *Teploenergetika* 1957, (9), 64–7 (D.S.I.R. translation C.T.S. 510).

Tests were made at pressures up to 180 atm, flow rates up to 10 m/s, and heat fluxes up to 4×10^6 kcal/m²h, with a water temperature between 1 and 140 C below saturation temperature. The results obtained agreed closely with those reported in the literature.

Steam Generation and Power Production

Equation of State, Thermodynamic Functions and Tables of Reference Points for Water and Superheated Steam up to 1000 atm abs and 1000 C. M. P. Bukalovich and B. V. Dzampov. *Teploenergetika* 1958, **5** (Apr.), 46–52 (In Russian).

With the aid of a state equation for superheated steam, valid up to ~1000 kg/cm² pressure, combined with numerical methods, tables of reference values of specific volume, enthalpy and entropy have been compiled. The tables embrace the range of water and steam conditions of 1–1000 kg/cm² and 0–1000 C in steps of 50 kg/cm² and 50 C.

From *C.E. G.B. Digest* 1958, **10** (Aug. 16), 2166.

Experimental Investigation of Compressibility of Water and Steam at Temperatures Near the Critical. V. A. Kirillin and S. A. Ulybin. *Teploenergetika* 1958, **5** (Apr.), 53–4 (In Russian).

From the test data on pressure, volume and temperature of steam around the critical points presented it is found that the experimental values of specific volumes of water and steam obtained are reliable within the limits quoted except for the range of 450–500 atm abs at the isotherm 410 C.

From *C.E.G.B. Digest* 1958, **10** (Aug. 16), 2168.

Investigation of the Effects of the Velocity of a Steam-Water Mixture in a Header on Its Distribution Over Parallel Tubes. V. I. Volkova. *Teploenergetika* 1957, (9), 37–40. (D.S.I.R. translation C.T.S. No. 501).

Non-dimensional parameters are developed for establishing the conditions under which distribution is uniform or not. From experiments, numerical values have been derived for these parameters at which distribution remains constant.

The Flow of Steam Water Mixtures Through Sharp-Edged Orifices. D. Chisholm. *Engng. Boil. Ho. Rev.* 1958, **73** (Aug.), 252–6.

An equation has been developed for calculating the flow of a steam-water mixture through a sharp-edged orifice. Theoretical and experimental results agree within ±10% for a dryness fraction of 0.11. The proposed parameter Y should also be useful in correlating two-phase flow friction data in tubes.

Pseudo-transition Locus for Water in the Supercritical Region. S. Ling. *Heat Engng.* 1958, **33** (Mar.-Apr.), 128–31.

An attempt is made to determine the pseudo-transition locus for various pressures by using two successive approximations. Rational results were obtained from the critical point up to 7000 psia, with an indication that the pseudo-transition temperature is an increasing function of pressure. Between 7000 and 10,000 psia irregularities occur.

The Behaviour of the Metal in Radiation Steam Superheaters Fixed to Boiler Walls. A. K. Vnukov. *Teploenergetika* 1957, (9), 45–8 (D.S.I.R. translation C.T.S. No. 500).

The cause of cracks in primary and secondary superheater tubes forming the side walls of a furnace were investigated. It was found that, during starting up, oil droplets impinged on the primary superheater tubes and caused local hot spots, heating the metal beyond its yield point. In the case of the secondary superheater tubes, the sharp temperature difference between the heated and unheated side (180–400 F) with a frequency of 2 to 6 cycles per sec caused thermal fatigue. The sudden changes of temperature were due to pulsation of the flame and were stopped by improvement of the combustion conditions.

Fabrication and Service Factors Involved in Failure of Welded Steam Receivers. A. J. Babecki and P. P. Puzak. *Welding J.* 1958, **37** (July), 329s–35s.

The results of investigation of cracked sections of three steam receivers are presented. The premature failure is ascribed to reduced fatigue strength as the result of mechanical stresses and strains at some unfavourable location, in combination with fabrication defects.

Practical Combustion Considerations in the Design of Packaged Economic-type Boilers. C. E. Woodley. *J. Inst. Fuel* 1958, **31** (Aug.), 356-61.

The considerations underlying the design of an oil burner and combustion chamber for an economic boiler and the calculation of heat transfer are outlined, and general remarks on flame radiation and density and viscosity of combustion gases added. The first appendix deals with tube plate layout and position of the combustion tubes and baffles, the second appendix gives a design example.

The B.C.R. Coal-fired Packaged Boiler. Anon. *Steam Engr.* 1958, **27** (Aug.), 370-5.

A detailed description is given of the 5-pass horizontal tube boiler, design and operation of the oscillating grate, the forced draught system, the controls, and test results.

Packaged Boilers. R. C. Bellas. *Power* 1958, **102** (Aug.), 77-100.

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This review of packaged boilers is divided into: (1) fire tube designs (2, 3 and 4-pass); (2) water tube designs (units up to 60,000 lb/h); (3) firing equipment (gas and oil burners, solid fuel stokers); (4) combustion controls; (5) safety controls; (6) high temperature water boilers; (7) operation and maintenance.

Improving Operating Efficiency of High-pressure Boilers. M. P. Rybakov. *Energetik* 1958, **6** (Apr.), 8-10 (In Russian).

Tests with high-pressure single-drum boilers using natural circulation (160 t/h, 940 psi., 400 C) show that arrangement of the feed tubes of the water-tube economizer to the drum with low feedwater velocities in the zone of high gas temperatures is unsuitable. A water velocity of 0.6–1 m/s in the baffle tubes of boilers with natural circulation is adequate for tube cooling. Since with forced circulation there is often considerable irregularity in water consumption along the economizer tubes, sometimes amounting to 40% of boiler output, it is necessary to increase the rated water velocity in the economizer tube operating in the high gas-temperature zone.

From *C.E.G.B. Digest* 1958, **10** (Aug. 16), 2157.

Furnaces and Combustion

The Mechanism of Combustion of Pulverised Fuel. P. 0. Rosin. *J. Inst. Fuel* 1958, **31** (Aug.), 346-55.

A review of the aerodynamical, thermodynamical, physical-chemical, and thermophysical process involved in the combustion of pulverised coal is presented and the inferences to be drawn from these on improvements in the combustion process and the reduction of boiler fouling are discussed.

The Length of Diffusion Flames of Gaseous Atomised Liquid and Solid Fuels. S. Traustel. *B.W.K.* 1958, **10** (Aug.), 367-9 (In German).

A method of calculating the shape and size of diffusion flames from circular free jet is developed. The length of turbulent flames is shown to be directly proportional to the mass flow of the fuel mixture divided by the square root of the jet impulse and the equation takes into account the combustion air requirements and density of the fuel mixture.

Water-Side Corrosion and Water Treatment

Corrosion of Steel in Water by Varied Rations of Dissolved Gases. J. W. Watkins and G. W. Kincheloe. *Corrosion* 1958, **14** (July), 55-8.

Corrosion caused by oxygen and free carbon dioxide increased in direct proportion to the concentration of dissolved oxygen. In ancillary studies of the effect of steel composition on corrosion rate, it was found that copper did afford corrosion protection whilst manganese, nickel and chromium did not.

Gas-Side Corrosion and Deposits

The Present Status of the Oil-Ash Corrosion Problem. N.A.C.E. Task Group T-5B-3 on Oil-Ash Corrosion. *Corrosion* 1958, **14** (Aug.), 33-6.

Several examples of severe corrosion by oil ash containing large amounts of sulfur and vanadium are reported, and the measures taken to reduce the rate of attack are discussed. These are: (1) a protective coating, which is not regarded as a very good solution; (2) additives, which must be chosen with regard to the alloys employed, the temperature conditions, and the vanadium, sodium and sulfur contents; (3) alloys selection is difficult, as none has been found resistant to oil-ash corrosion in the temperature range of 1600 to 1800 F; (4) design changes, which should aim at lowering the temperature. The necessity of further research in all these fields is stressed.

Flue Gas, Ash and Dust

From Coal to Concrete. Annon. *Coal Utilization* 1958, **12** (July), 21-2.

Detroit Edison Co. produce about 340,000 tons of fly ash per year, of which about 105,000 tons are sold at $1 per ton for asphalt paving mixes, concrete mixes, and concrete products. Further extensions of sales of fly ash are hoped for from a process of sintering fly ash into light weight aggregate for building blocks, which has proved satisfactory on the laboratory scale, but has not yet been tried out on a large scale.

Heat Recovery Plant

Extended Heat Exchange Surface for Marine and Nuclear Boilers. R. E. Zollner. *N. E. Coast Inst. of Engrs. and Ship Bldrs. paper* 1958 (Jan. 24) 40pp.

The paper reports 418 tests on sixteen combinations of extended heating surface suitable for a nuclear heat-exchanger, a boiler or its associated economizer. Each test series is analyzed by means of simplified heat-transfer and draught-loss formulae. Sufficient information is given to allow extrapolation of the tests to conditions obtaining in gas-cooled atomic nuclear piles. Laboratory tests are compared with the

trial results of economizers on highly rated boilers.

From *C.E.G.B. Digest* 1958, **10** (Aug. 16), 2208.

To Clean Your Condenser—Backwash Is Cheapest. T. E. Hitzeman and H. W. Feist. *Pwr. Engng.* 1958, **62** (July), 72-4.

Removal of debris from inside the tubes of condensers can be done, without interrupting turbine operation, by the backwash method if the condenser is or can be divided into at least two separate parts. A fully automatic time sequence control system for backwashing condensers is outlined briefly.

Power Generation and Power Plant

Reheat Practice in British Power Stations. II. F. H. S. Brown and J. W. H. Dore. *Steam Engr.* 1958, **27** (Aug.), 384-7.

The second part traces the development of steam turbines and generators for ratings of up to 275 MW.

Trends in Power Generation. H. E. Roberts. *Nucleonics* 1958, **16** (July), 76-9.

A survey is given of the trends in American steam power station size, capacity of individual units, net heat rate, and cost of unit generated. The latest most efficient plants run almost continuously and it is thus argued that when computing potential costs of nuclear power stations this could also be based on a high load factor.

Power Station Reactors—America Looks Ahead. Anon. *Atomics & Nucl. Energy* 1958, **9** (Aug.), 264-7.

A survey is given, based in on a report by the U. S. Atomic Energy Commission to a Congressional Committee, in which all power reactors planned for the period 1959-60 are tabulated, together with their thermal and electrical power, moderator, coolant, fuel and canning material, and the purpose of the wide diversification of effort is discussed.

American Prospects for Economic Nuclear Power. W. K. Davis and L. H. Roddis. *Atomics & Nuclear Energy* 1958, **9** (Aug.), 268-70, 279.

Estimates of cost of power produced in nuclear power plants are given and compared with those of conventional power stations. It is though that costs are unlikely to become competitive before the end of the 1970's.

Materials and Manufacturing Processes

New Engineering Metals. J. P. Denny and L. E. Rendall. *Mech. Engng.* 1958, **80** (Aug.), 67-71.

The mechanical properties and present and potential future uses are described of zirconium, hafnium, vanadium, columbium (niobium), tantalum, chromium, and rhenium.

Forgeable High Strength Austenitic Alloy Steel with Molybdenum, Tantalum or Nibium-Tantalum and Nitrogen Additions. Babcock & Wilcox Ltd. British Patent 800, 225 U.S.A., 30th July, 1954.

Four austenitic steel compositions suitable for superheater tubes operating above 1350 F and 2000 psi are listed, which contain 14-20% Cr, 12-18% Ni, 0.02-15% C, 0.25-2.5% Mn, 0.1-1% Si, 0.5-2.06% Ta or Ta-Nb, 1-3% Mo, 0.1-0.25% N, 2-3% Cu, and 0.11-0.21% V, balance iron.

Beryllium Machining Characteristics. D. R. Walker. *Mech. Engng.* 1958, **80** (Aug.), 57-62.

The machining characteristics of beryllium have been investigated by means of spark pictures, to establish the best method. The tools to use, cutting speeds, and feeds are set out in detail.

Fundamentals of Brazing for Elevated-temperature Service. M.

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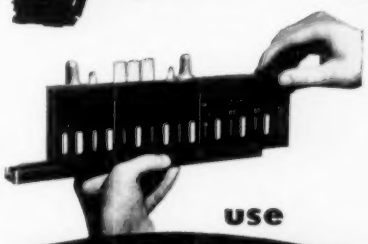

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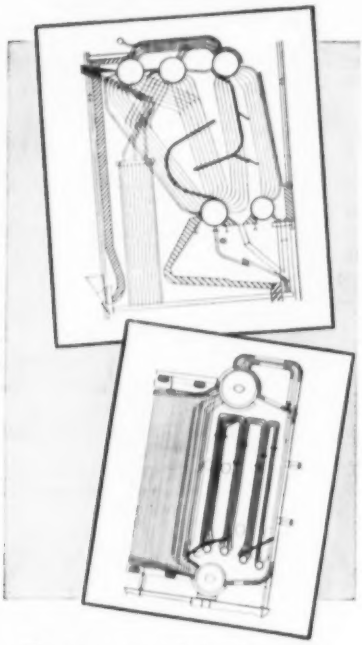

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D. Bellware. *Welding J.* 1958, **37** (July), 683-91.

A review is presented of commercially available brazing alloys, their range of application, and the brazing methods developed for each kind. In particular, the alloys and methods suitable for application between 1000 and 2000 F are discussed and examples illustrated.

Development of the Tungsten-Arc Cutting Process. R. A. Cresswell. *Brit. Weld. J.* 1958, **5** (Aug.), 346-55.

The tungsten-arc process described in detail produces clean cuts at high speeds on various metals such as Al, Cu, and steels, and appears to be specially economic for cutting stainless steel. The cut surfaces are suitable for welding without further preparation. Adequate ventilation is required to prevent health hazards from fumes.

From *author's abstract.*

Application of the Numerical Analogue System to Oxygen Cutting Machines. L. J. Hancock and J. R. Arrowsmith. *Brit. Weld. J.* 1958, **5** (Aug.), 369-73.

An automatically controlled oxygen cutting machine fitted with a numerical analogue control system is described, which permits automatic operation without the use of templates or facsimile drawings. The advantages and applications of the system are discussed.

From *author's abstract.*

Stress Relieving of Stainless Steel and Associated Metallurgy. R. A. Huseby. *Welding J.* 1958, **37** (July), 304s-15s.

The factors governing the stress relieving of the several types of stainless steels are discussed in detail and the reasons given where stress relieving is necessary or advantageous and where it should not be applied.

Dimensioning for Accurate Fabrication. A. G. Thompson. *Weld Met. Fabric.* 1958, **26** (Aug.), 298-302.

Dimensioning for butt and fillet welds is discussed with regard to the undesirable consequences if the edge dimensions of adjoining parts are inaccurate. Initial and final dimensions, methods of obtaining and transferring dimensions, templates, and photographic methods are described.

Research in Welding. P. L. J. Leder. *Elect. Rev.* 1958, **163** (Aug. 1), 189-93.

A review of recent developments in the automatic continuous covered-electrode process, manual covered-electrode welding, semi automatic and fully automatic submerged arc welding, and gas shielded welding processes. The efficient uses of the various processes and power sources for welding are also discussed.

Automatic Welding of Aluminum Plate. J. E. Tomlinson and D. Slater. *Brit. Weld. J.* 1958, **5** (Aug.), 361-8.

Tests are described in which individual variations of process variables are studied and the results are used to predict welding conditions for high quality close square butt welding of plates up to $^5/_8$ in. thick. The variables studied include inclination of welding head, arc voltage, welding current, welding speed, edge preparation, and root gaps.

Automatic Welding of Stainless Clad Material. Anon. *Weld. Met. Fabric.* 1958, **26** (Aug.), 277.

The stainless steel side of plates ($^1/_4$ in., cladding 20% of thickness) was automatically welded, using a stainless steel electrode wire and agglomerated type flux in one pass. Currents in the order of 350 amp and speeds of 32 to 42 in./min. were employed. The mild steel side was welded with a current of 875 to 900 amp and a speed of 30 to 34 in./min.

Gas-Electric Welding with Constrained Moulded Joints. D. A. Dudko and F. M. Vinogradskii. *Weld. Met. Fabric.* 1958, **26** (Aug.), 289-90.

A process has been developed in Russia for automatic welding of vertical joints in plates of medium thickness (0.31 to 1.5 in.) in which a gas-protected arc and a constraining mould are used. Joints made by this process are illustrated. This method has now been extended to cover thicker plates and tubes, and details are given of electrodes and currents employed and of the consumption of gas.

Inert-Gas Tungsten-Arc Welding of Titanium for Nuclear and Chemical Industries. G. M. Adamson and W. J. Leonard. *Welding J.* 1958, **37** (July), 673-82.

The process developed for field welding unalloyed titanium is described. It is intended for high quality individual welds and not for repetitive production welds.

Properties of Fusion Welds in Unalloyed Titanium and Ti 5% Al-2½% Sn Alloy Sheet. J. C. Borland and W. C. Hull. *Brit. Weld. J.* 1958, **5** (Aug.), 374-80.

Tests on butt welds made in a closed chamber containing high purity argon are reported. The results are discussed with reference to porosity, mechanical properties, and hardness.

Some Applications of Cold Pressure-Welding. Anon. *Machinery* 1958, **93** (July 25), 207-13.

Cold pressure welding of non-ferrous metal parts and surface preparation for lap and extrusion welding are described and the reliability of such welds is discussed.

Role of Phosphorus in Austenitic Manganese Weld Metal. W. T. Delong, W. C. Lutes and H. F. Reid. *Welding J.* 1958, **37** (July), 316s–9s.

A comparative study of five different nickel-manganese electrodes to find the reasons for the outstanding mechanical properties of the weld metal deposited by one of these showed that this particular electrode had a phosphorus content less than half of that of the other electrodes. Further investigations showed that nickel-manganese weld metals with phosphorus content reduced to 0.01–0.02% (maximum 0.035%) had very high tensile strength, ductility and crack resistance. The same is valid for molybdenum-manganese weld metals.

Instruments and Controls

Central Station Control—To-day and To-morrow. W. A. Summers. *Combustion* 1958, **30** (July), 34–42.

An automatic control system governing starting, stopping, loading, and switching units, to reduce capital, replacement and operating costs, is outlined. The components required for such a system and their functions are described, and examples of the type of control system envisaged are presented.

Automatic Data System Keeps Tabs on Sterlington Power Plant. L. E. Stewart. *Power* 1958, **102** (Aug.), 104–5.

A data logging system, including a transistorized digital computer, has been installed at Sterlington Power Station, to check 350 data points a second, including 250 temperature points, and to provide continuous data on heat rate, temperatures, pressures and flow. The system consists of four sections: (1) input, where the measurements are sequentially connected for reading; (2) digital, where analogue signals are converted to digital values; (3) computer, where the calculations are carried out, such as temperature differences and heat rates; (4) output, where final logging, printing and annunciation takes place. The computer contains a magnetic memory storing 2048 pieces of information which can be extended to 16,384. Incoming signals such as voltages produced by thermocouples are converted to temperatures by means of thermocouple calibration curves stored in the computer; the accuracy is one part in one million. If given limits are exceeded, an alarm is actuated and a special alarm printer provides time, reading and location. The data are printed on a tape and this is fed to typewriters which print the results.

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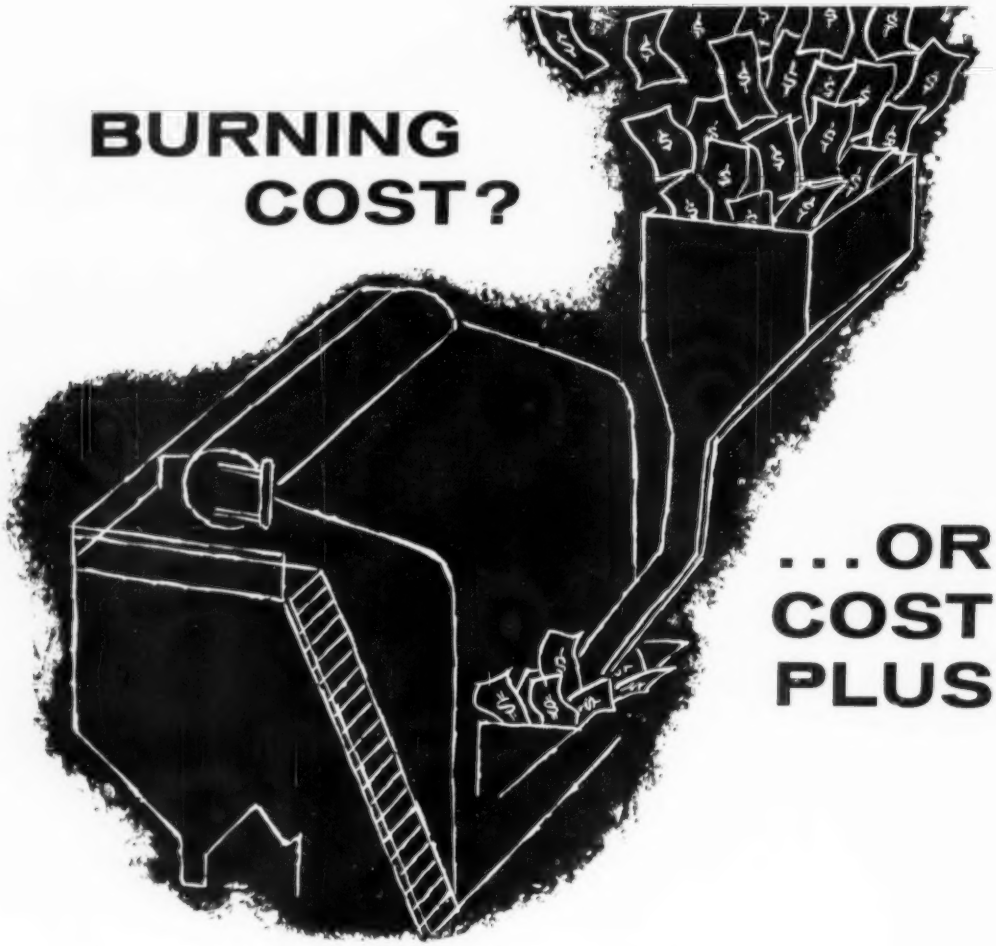

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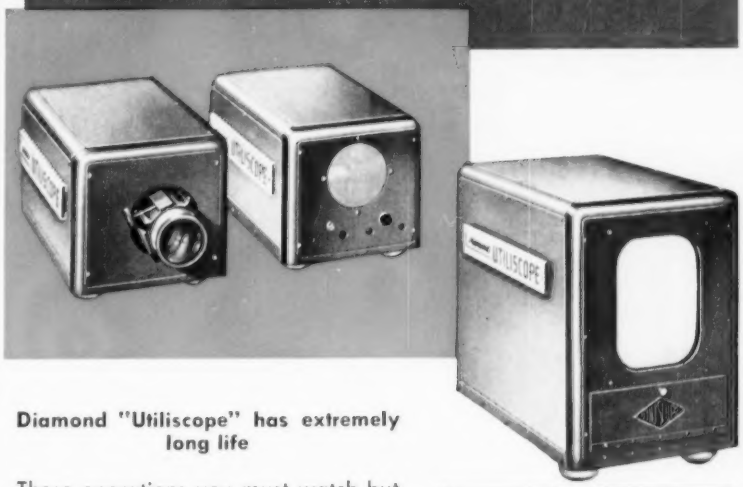

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HOW YOUR PLANT CAN PROFIT FROM THIS MAN'S SKILL. Dowell engineers are experts in the use of chemical solvents to remove scale and sludge—those profit-robbing deposits that cut the capacity of your process systems, tanks, piping. Using the Dowell method of chemical cleaning you get more throughput, less down time—to make possible greater overall plant efficiency.

Here's how one corporation employed the skill of the Dowell engineer and his group: Following construction and before the plant was put on stream, the company called in Dowell to remove mill scale.

Total cost of this mill scaling service was $5000. Once in production the plant did not have a single major shut-down for maintenance due to mill scale. Management of the plant credits Dowell service with helping them net an operating profit of somewhere between 10 and 20 times the cost of the chemical cleaning. That amounted to between $50,000 and $100,000 the first year.

With Dowell service you get 15 years experience in chemical cleaning, full lines of equipment and chemicals—plus an engineered job—performed by trained crews.

Every type of industry can profit from Dowell methods of chemical cleaning. Ask your maintenance and operating engineers if they have all the facts—the profit possibilities—on Dowell service. DOWELL—A SERVICE DIVISION OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa 1, Oklahoma; 165 offices and stations to serve you.

Chemical cleaning services for industry DOWELL